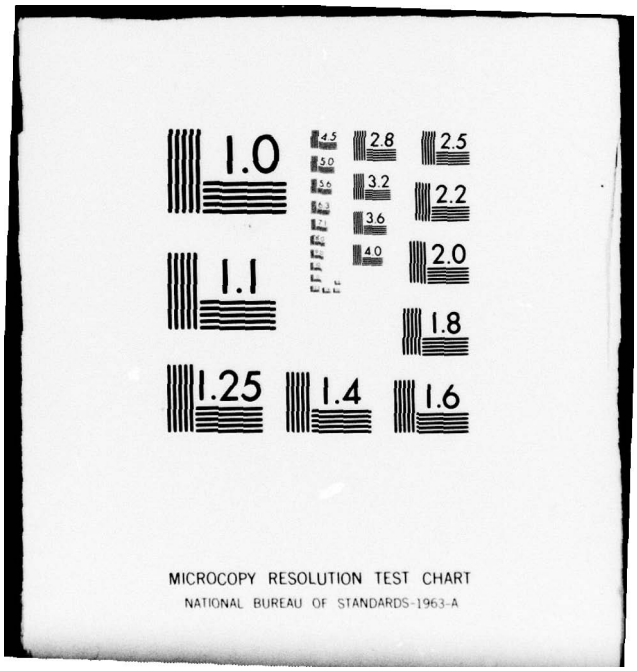
AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

1 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12) LEVEL II

CCP 702-11



Product Assurance

QUALITY ASSURANCE

DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES

30 SEPTEMBER 1979

AD A079518

VOICE OF THE ARMY

DDC RECEIVED JAN 17 1980 A

DDC FILE COPY

DISTRIBUTION STATEMENT

Approved for public release. Distribution unlimited.

HEADQUARTERS
U. S. ARMY COMMUNICATIONS COMMAND
FORT HUACHUCA, ARIZONA 85613

80- 3 1 179

DISPOSITION INSTRUCTIONS

Destroy this document when no longer needed. Do not return it to the originator.

AVAILABILITY STATEMENT

This publication is available for public sale through the Defense Documentation Center, Cameron Station, Alexandria, VA 22314.

DISCLAIMER

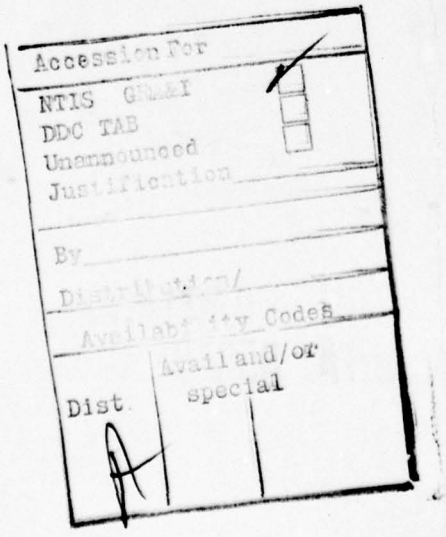
The contents of this document are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The use of trade names in this document does not constitute an official endorsement or approval of the use of such commercial hardware or software. This document may not be cited for purpose of advertisement.

WARNING

CARE MUST BE TAKEN DURING TESTING TO PRECLUDE PERSONAL INJURY OR LOSS OF LIFE FROM HIGH VOLTAGES.

NOTICE
The procedures contained in this document have not been tested in the field. Comments and recommendations of team members actually engaged in testing are solicited. Comments should be submitted in accordance with the proponency statement at the back of the document.



(14) ACC-CCP-702-11

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: CCP 702-11

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

(6) 4. TITLE (and Subtitle): DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES, Quality Assurance,

5. TYPE OF REPORT & PERIOD COVERED: Communications Command Pamphlet

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s):
US Army Communications Command
ATTN: CC-OPS-OQ
Fort Huachuca, AZ 85613

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
US Army Communications Command
ATTN: CC-OPS-OQ
Fort Huachuca, AZ 85613

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: (12) 1Q42

11. CONTROLLING OFFICE NAME AND ADDRESS:
US Army Communications Command
ATTN: CC-PA-AMP
Fort Huachuca, AZ 85613

(11) 12. REPORT DATE: 30 Sept[illegible]979

13. NUMBER OF PAGES: 1046

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
This document is available for public sale through the Defense Documentation Center, Cameron Station, Alexandria, VA 22314.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
AN/FRC-162
AN/FRC-( )
VICOM 4000-2
TD-1192 (AN/FCC-98)
TD-1193
AN/FCC-97
AN/GSC-24

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This pamphlet contains the basic test procedures, test equipment configurations, specifications, and data recording requirements for quality assurance, quality control, and test and acceptance of the digital radio, multiplex, and associated circuits. Worksheets and tutorial information on test techniques and data analysis as well as extracts of technical literature are included to aid in the assessment of the equipment and systems.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

408 562

50B

DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY COMMUNICATIONS COMMAND
FORT HUACHUCA, ARIZONA 85613

USACC Pamphlet
No. 702-11

30 September 1979

Product Assurance

QUALITY ASSURANCE

DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES

TABLE OF CONTENTS

			Paragraph	Page
Chapter	1.	INTRODUCTION		
		General	1-1	1-1
		Applicability	1-2	1-1
		Scope	1-3	1-1
		Discussion	1-4	1-1
		Testing Philosophy	1-5	1-6
		System Measurements	1-6	1-11
		Data Recording and Analysis	1-7	1-12
		References	1-8	1-12
Chapter	2.	DIGITAL RADIO QUALITY ASSURANCE TEST TEAM MEMBER FUNCTIONS AND RESPONSIBILITIES		
		General	2-1	2-1
		Test Team Composition	2-2	2-1
		Test Team Responsibilities	2-3	2-2
		Administrative Requirements	2-4	2-6
		Logistical Support	2-5	2-7
Chapter	3.	ANTENNA ALINEMENT (DT-200)		3-1
	4.	TIME DOMAIN REFLECTOMETRY (TDR) OF ANTENNA TRANSMISSION LINES (DT-201)		4-1
	5.	FREQUENCY DOMAIN REFLECTOMETRY OF ANTENNA TRANSMISSION LINES (DT-202)		5-1
	6.	RETURN LOSS VS DISTANCE PROFILE OF TRANSMISSION LINES AND ANTENNA SYSTEMS (DT-203)		6-1

			Page
Chapter	7.	INSERTION AND RETURN LOSS (AUDIO METHOD) (DT-204). .	7-1
	8.	INSERTION AND RETURN LOSS (AUTOMATIC METHOD) (DT-205)	8-1
	9.	GROUP DELAY (DT-206)	9-1
	10.	RF INTERFACE INPUT/OUTPUT RETURN LOSS (DT-207)	10-1
	11.	RADIO EQUIPMENT AND LINK BASEBAND LEVEL VS FREQUENCY (DT-208)	11-1
	12.	RADIO EQUIPMENT BASEBAND ENVELOPE DELAY (DT-209)	12-1
	13.	BASEBAND AND RADIO SWITCHING (DT-210).	13-1
	14.	MESSAGE BASEBAND INTERFACE (THREE-LEVEL, PARTIAL-RESPONSE RADIO) (DT-211)	14-2
	15.	DIGITAL RADIO INPUT/OUTPUT (DT-212).	15-1
	16.	SUPERVISORY BASEBAND FREQUENCY RESPONSE, CROSSTALK, AND NOISE PERFORMANCE (DT-213).	16-1
	17.	SUPERVISORY BASEBAND INTERFACE (DT-214).	17-1
	18.	RADIO ORDERWIRE (DT-215)	18-1
	19.	RADIO ORDERWIRE SUBCARRIER FREQUENCY AND STABILITY (DT-216)	19-1
	20.	RADIO PILOT CONTINUITY AND STABILITY (DT-217). . . .	20-1
	21.	RECEIVER BASEBAND LINEARITY AND GROUP DELAY (DT-218)	21-1
	22.	LINK BASEBAND LINEARITY AND GROUP DELAY (DT-219) . .	22-1
	23.	TRANSMIT RF AND RECEIVE BASEBAND SPURIOUS EMISSIONS, AND RECEIVE RADIO INTERFERENCE (DT-220)	23-1

Page

Chapter 24. RECEIVER LOCAL OSCILLATOR SPURIOUS EMISSIONS, FREQUENCY ACCURACY, STABILITY, AND IMAGE REJECTION (DT-221) 24-1

25. RADIO FREQUENCY SPECTRUM BANDWIDTH (DT-222). 25-1

26. RECEIVER NOISE FIGURE (DT-223) 26-1

27. RECEIVER RF INPUT POWER VS AGC OR IF VOLTAGE QUIETING CHARACTERISTICS (DT-224). 27-1

28. RECEIVER TIMING OUTPUT (DT-225). 28-1

29. RECEIVER PERFORMANCE (DT-226). 29-1

30. RF RECEIVER INTERMODULATION (DT-227) 30-1

31. RF RECEIVER ADJACENT AND COCHANNEL INTERFERENCE (DT-228). 31-1

32. RECEIVER CARRIER AND CLOCK RECOVERY (DT-229) 32-1

33. TRANSMITTER AND RECEIVER MONITORING AND ALARM FUNCTIONS (DT-230) 33-1

34. MONITOR AND ALARMS, AN/FRC-162 RADIO (DT-231). . . . 34-1

35. TRANSMITTER-RECEIVER ISOLATION (DT-232). 35-1

36. TRANSMITTER OUTPUT POWER AND ANTENNA SYSTEM REFLECTED POWER (DT-233). 36-1

37. TRANSMITTER MODULATOR FREQUENCY DEVIATION AND LINEARITY (DT-234) 37-1

38. TRANSMITTER DEMODULATOR LINEARITY (DT-235) 38-1

39. TRANSMITTER FREQUENCY ACCURACY AND STABILITY (DT-236) 39-1

40. ORDERWIRE SUBCARRIER FREQUENCY DEVIATION (DT-237) 40-1

41. RECEIVER FREQUENCY RESPONSE AND POWER GAIN (DT-238). 41-1

			Page
Chapter	42.	RECEIVER AUTOMATIC FREQUENCY CONTROL (DT-239). . .	42-1
	43.	TRANSMITTER AUTOMATIC FREQUENCY CONTROL (DT-240)	43-1
	44.	TRANSMITTER RF POWER GAIN AND BANDWIDTH (DT-241)	44-1
	45.	RECEIVER INTERMEDIATE FREQUENCY BANDWIDTH DISCRIMINATOR (DT-242)	45-1
	46.	RECEIVER PHASING (DT-243).	46-1
	47.	TEST TONE VARIATION (DT-244)	47-1
	48.	INPUT POWER VERIFICATION (DT-245).	48-1
	49.	RADIO TRANSIENT PROTECTION (DT-246).	49-1
	50.	REVERSE POLARITY PROTECTION (DT-247)	50-1
	51.	POWER SUPPLY PROTECTION (DT-248)	51-1
	52.	BIT ERROR RATE (AN/FRC-162) (DT-249)	52-1
	53.	MBS AND SCBS INPUT/OUTPUT CABLE REQUIREMENTS (DT-250).	53-1
	54.	RADIO EMISSION PARAMETERS AND MBS RATES (DT-251)	54-1
	55.	SCBS INTERFACE REQUIREMENTS (DT-252)	55-1
	56.	TRANSMIT TIMING OUTPUT (DT-253).	56-1
	57.	LOCKUP AND INTERFACE PROTECTION (RADIO) (DT-254).	57-1
	58.	SIGNAL PERFORMANCE MONITOR (DT-255).	58-1
	59.	RF TRANSMITTER AFC CHARACTERISTICS (DT-256). . . .	59-1
	60.	TRANSMITTER MODULATOR FREQUENCY DEVIATION AND LINEARITY (DT-257)	60-1

Page

Chapter 61. RECEIVER RF INPUT VS AGC OR IF VOLTAGE (RECEIVER QUIETING) (DT-258) 61-1

62. RECEIVER BASEBAND LINEARITY AND GROUP DELAY (AN/FRC-162) (DT-259). 62-1

63. FAULT ALARM STATUS REPORTING (FASR) EQUIPMENT (DT-260). 63-1

64. DATA CHANNEL AND MULTIPLEX INPUT/OUTPUT INTERFACE PERFORMANCE (DT-261) 64-1

65. TEST TONE SIGNAL AND CUSTOMER LEVELS (DT-262) 65-1

66. INSERTION LOSS VS FREQUENCY (AUTOMATIC METHOD) (DT-263). 66-1

67. VOICE CHANNEL FREQUENCY RESPONSE (MANUAL METHOD) (DT-264) 67-1

68. IDLE VOICE CHANNEL CIRCUIT NOISE (DT-265). 68-1

69. IDLE CHANNEL IMPULSE NOISE (DT-266). 69-1

70. VOICE CHANNEL CROSSTALK (DT-267) 70-1

71. VOICE CHANNEL ENVELOPE DELAY DISTORTION (AUTOMATIC METHOD) (DT-268). 71-1

72. VOICE CHANNEL ENVELOPE DELAY DISTORTION (MANUAL METHOD) (DT-269) 72-1

73. VOICE CHANNEL INTERMODULATION DISTORTION (DT-270). 73-1

74. VOICE CHANNEL HARMONIC DISTORTION (DT-271) 74-1

75. CIRCUIT NOISE AND SINGLE TONE INTERFERENCE (DT-272) 75-1

76. E&M SIGNALING (DT-273) 76-1

77. MULTIPLEX LOOPBACK AND LOOPBACK ALARM (DT-274) 77-1

			Page
Chapter	78.	CARRIER GROUP ALARM (DT-275)	78-1
	79.	SIGNAL-TO-NOISE QUANTIZING (S/Nq) DISTORTION (DT-276).	79-1
	80.	MULTIPLEX TERMINAL END-TO-END COMPATIBILITY AND PERFORMANCE REQUIREMENTS (DT-277).	80-1
	81.	VOICE FREQUENCY CHANNEL INPUT/OUTPUT IMPEDANCES (AUTOMATIC METHOD) (DT-278)	81-1
	82.	VOICE FREQUENCY CHANNEL INPUT/OUTPUT IMPEDANCES (MANUAL METHOD) (DT-279).	82-1
	83.	IMPEDANCE MEASUREMENTS (BRIDGE METHOD) (DT-280)	83-1
	84.	VOICE FREQUENCY CHANNEL INPUT/OUTPUT INTERFACE LEVEL (DT-281)	84-1
	85.	VOICE FREQUENCY CHANNEL INPUT/OUTPUT LINEARITY (DT-282)	85-1
	86.	VOICE FREQUENCY CHANNEL LEVEL STABILITY (DT-283)	86-1
	87.	VOICE FREQUENCY CHANNEL LONGITUDINAL BALANCE (DT-284)	87-1
	88.	VOICE FREQUENCY CHANNEL BIT ERROR RATE (DT-285)	88-1
	89.	TD-1192 (AN/FCC-98) BIT ERROR RATE AND BIT COUNT INTEGRITY (DT-286)	89-1
	90.	TD-1192 (AN/FCC-98) BIT ERROR RATE AND BIT COUNT INTEGRITY USING BITE (DT-287).	90-1
	91.	BIT ERROR RATE AND BIT COUNT INTEGRITY OF THE VICOM 4000-2 (DT-288).	91-1
	92.	BIT ERROR RATE AND BIT COUNT INTEGRITY OF THE 2D LEVEL MULTIPLEX (1.544 mb/s AND ABOVE) (DT-289)	92-1

Page

Chapter 93. DIGITAL TRANSMISSION SYSTEM BIT ERROR RATE (DT-290) 93-1

94. SYSTEM DATA CHANNEL AND TIMING JITTER (DT-291) 94-1

95. MULTIPLEX TRANSMIT TIMING ACCURACY AND STABILITY (DT-292) 95-1

96. BIPOLAR AND NRZ DATA CHANNEL PORT INPUT AND OUTPUT IMPEDANCES (DT-293) 96-1

97. MULTIPLEX INPUT/OUTPUT VOLTAGE LEVELS (DT-294) 97-1

98. CODER/DECODER (DT-295) 98-1

99. DIGITAL INTERFACE RISE AND FALL TIMES (DT-296) 99-1

100. DATA AND TIMING SIGNAL RINGING (DT-297). 100-1

101. FRAME SYNCHRONIZATION ACQUISITION AND REACQUISITION TIME (DT-298). 101-1

102. DATA AND TIMING SIGNAL PHASING AND SAMPLING INTERVAL (DT-299). 102-1

103. EXTERNAL TIMING SOURCE AND RECEIVE TIMING OUTPUT (DT-300). 103-1

104. COMBINED EFFECTS OF JITTER (DT-301). 104-1

105. TD-1192 (AN/FCC-98) AND TD-1193 MONITOR AND ALARMS (DT-302). 105-1

106. PROTECTION SWITCHING AND ALARM OPERATION OF THE AN/FRC-162 AND VICOM 4000-2 SYSTEM (DT-303) 106-1

107. BUILT-IN TEST EQUIPMENT (DT-304) 107-1

108. DATA CHANNEL CHARACTERISTICS (50 kb/s) (DT-305) 108-1

			Page
Chapter	109.	LOCKUP AND INTERFACE PROTECTION (MULTIPLEX) (DT-306)	109-1
	110.	TIME DIVISION MULTIPLEX INTERFACE CHARACTERISTICS AND PERFORMANCE (DT-307)	110-1
	111.	MULTIPLEX/DEMULTIPLEX INPUT POWER (DT-308)	111-1
	112.	BATTERY PLANT (DT-309)	112-1
	113.	DC POWER AND DISTRIBUTION SYSTEM (DT-310)	113-1
	114.	MULTIPLE PARAMETER DATA RECORDING (DT-311)	114-1
	115.	RESISTANCE OF STATION GROUND AND STATION NOISE (DT-312)	115-1
APPENDIX	A.	SPECIFIED TMDE OR EQUIVALENT	A-1
	B.	SAMPLE REPORT	B-1
	C.	DCA CIRCUIT PARAMETERS	C-1
	D.	ABBREVIATIONS	E-1

LIST OF ILLUSTRATIONS

Figure	1-1.	Typical test point designations (transmit)	1-14
	1-2.	Typical test point designations (receive)	1-15
	1-3.	Test point design data sheet	1-16
	1-4.	Three-level, partial-response radio link bit error rate (BER) test setup	1-17
	1-5.	Typical back-to-back BER test setup	1-18
	1-6.	Typical AN/FRC-162 and AN/FCC-97 system (receive)	1-19
	1-7.	Typical AN/FRC-162 and AN/FCC-97 system (transmit)	1-20
	1-8.	Typical frequency diversity system (fully digital)	1-21
	1-9.	Typical space diversity terminal (fully digital) link-loop test setup	1-22
	3-1.	RSL recording test setup	3-7
	3-2.	Radio link recorded parameters cumulative probability distribution stroke chart data sheet	3-8
	3-3.	Antenna alinement (fast scan method) data sheet	3-9
	3-4.	General purpose graph data sheet	3-10
	3-5.	Typical plot of RSL	3-11
	3-6.	Antenna alinement (run-median method) data sheet	3-12

Page

Figure 3-7. Test cover sheet 3-13
4-1. Transmission line TDR test setup 4-4
4-2. Typical return loss vs distance of transmission line 4-5
5-1. RF transmission line test setup. 5-5
5-2. General purpose photo recordings data sheet. . . . 5-8
6-1. Typical antenna test points. 6-8
6-2. Return loss vs distance test setup 6-9
6-3. Typical distance calibration pulse 6-10
7-1. Insertion loss (audio method) test setup 7-7
8-1. Insertion loss (X-Y recorder) test setup 8-7
8-2. Insertion loss (photographic method) test setup. . 8-8
8-3. Typical insertion loss measurement 8-9
8-4. Return loss test setup 8-10
8-5. Frequency response test setup. 8-11
8-6. Typical return loss measurement. 8-12
8-7. Insertion and return loss test setup 8-13
8-8. Typical insertion and return loss measurements . . 8-14
9-1. Group delay test setup 9-4
9-2. Typical group delay filter measurment. 9-5
10-1. RF interface input/output return loss test setup . 10-4
10-2. RF interface BER test setup. 10-5
11-1. Radio equipment and link baseband level vs frequency 11-4
11-2. Typical signal flow (service channel) (AN/FRC-162 radio) 11-5
11-3. Typical signal flow (AN/FRC-162 radio baseband). . 11-6
11-4. Message baseband interface data sheet. 11-7
12-1. Radio equipment baseband envelope delay test setup 12-5
13-1. Back-to-back switching with multiplex test setup 13-13
13-2. Switching performance data sheet 13-14
13-3. Back-to-back switching without multiplex test setup 13-15
13-4. Switching and BER performance data sheet 13-16
13-5. Switching error test setup 13-17
14-1. Baseband interface (bridge) (calibration). 14-5
14-2. Baseband interface (bridge) test setup 14-6
14-3. Baseband return loss (comparison) test setup . . . 14-7
14-4. Impedance conversion chart 14-8
15-1. Typical timing and NRZ waveforms (AN/FRC-( )). . . 15-12
15-2. Data and timing phase relationships. 15-13
15-3. Data and timing relationships (phasing) trailing edge. 15-14
15-4. Percentage of nominal data unit interval 15-15

			Page
Figure	15-5.	Digital radio interface using TD-1193 and TD-1192.	15-16
	15-6.	Digital radio interface using TD-1192 and AN/GSC-24.	15-17
	15-7.	Digital radio interface using TD-1193, TD-1192, and TSEC/KG-81	15-18
	15-8.	Digital radio interface test setup	15-19
	15-9.	Digital radio interface data sheet	15-21
	15-10.	Input/output impedance calibration and test setup.	15-23
	15-11.	Digital radio input/output voltage test setup. . .	15-24
	15-12.	Input voltage and data and timing jitter test setup.	15-25
	16-1.	Supervisory baseband level vs frequency (manual) test setup.	16-7
	16-2.	Typical signal flow (service channel).	16-8
	16-3.	Typical signal flow (receive supervisory channel).	16-9
	16-4.	Voice channel measurement data	16-10
	16-5.	Supervisory baseband level vs frequency response (automatic) test setup.	16-11
	16-6.	Supervisory baseband crosstalk test setup.	16-12
	16-7.	Supervisory baseband crosstalk and noise data sheet	16-13
	17-1.	Supervisory baseband return loss (bridge) test setup	17-5
	17-2.	Supervisory baseband input characteristics data sheet	17-6
	18-1.	Radio orderwire characteristics (vector impedance bridge) test setup	18-8
	18-2.	Radio orderwire characteristics data sheet	18-9
	18-3.	Radio orderwire impedance (comparison method, calibration) test setup.	18-10
	18-4.	Radio orderwire impedance (comparison method) test setup	18-11
	18-5.	Radio orderwire impedance using DMS calibration and test setup	18-12
	18-6.	Radio orderwire impedance (automatic method) test setup	18-13
	19-1.	Radio orderwire subcarrier frequency accuracy test setup	19-3
	19-2.	Transmitter RF carrier/receiver local oscillator frequency accuracy data sheet.	19-4
	20-1.	Radio pilot, continuity, and stability test setup.	20-4
	21-1.	Receiver baseband linearity and group delay (RF to baseband) calibration and test setup.	21-6
	21-2.	Typical linearity and delay response curve, microwave link analyzer presentation	21-7

Page

Figure 21-3. Typical receiver baseband linearity and group delay (IF to baseband) test setup. 21-8
22-1. Link baseband linearity and group delay test setup 22-5
22-2. Radio baseband delay and linearity, using a delay and linearity test set, test setup 22-6
22-3. Typical delay characteristics. 22-7
23-1. Frequency spectrum analysis data summary 23-7
23-2. Radio spectrum analysis test setup 23-8
24-1. Receiver local oscillator test setup 24-9
24-2. Recorded data summary. 24-10
24-3. Local oscillator performance test setup. 24-11
24-4. Receiver local oscillator (calculator method) test setup 24-12
24-5. Receiver local oscillator image rejection data sheet 24-13
25-1. Radio frequency spectrum bandwidth test setup. . . 25-6
25-2. Typical overlay of spectrum bandwidth (AN/FRC-162) 25-7
26-1. Receiver noise figure data sheet 26-5
26-2. Receiver noise figure test setup 26-6
27-1. Receiver FM quieting data sheet. 27-6
27-2. Receiver noise quieting test setup 27-7
27-3. Receiver noise quieting profile data sheet 27-8
27-4. Typical receiver noise quieting curve (FM radio) . 27-9
28-1. Receiver recovered timing calibration and test setup. 28-6
28-2. Recovered receive timing data sheet. 28-7
28-3. Output voltage level test setup. 28-8
29-1. Receiver performance test setup. 29-8
29-2. Receiver performance data sheet. 29-9
29-3. Cumulative probability distribution stroke chart . 29-10
29-4. General purpose probability distribution graph . . 29-11
29-5. Distributions of run median RSL and V.CH. noise. . 29-12
30-1. RF receiver intermodulation test setup 30-4
30-2. Receiver intermodulation data sheet. 30-5
31-1. RF receiver interference test setup. 31-5
31-2. RF receiver interference data sheet. 31-6
32-1. Receive carrier and clock recovery test setup. . . 32-3
32-2. Carrier and clock recovery data sheet. 32-4
33-1. Block diagram of monitor and alarm unit, half terminal. 33-8
33-2. Digital radio monitor and alarm data sheet 33-11
33-3. Monitor and alarm (transmit power) test setup. . . 33-13
34-1. Monitor and alarm (AN/FRC-162) test setup. 34-9
34-2. Monitor and alarms (AN/FRC-162 radio) data sheet . 34-10
34-3. Transmit power monitor assembly (AN/FRC-162) test setup. 34-11

			Page
Figure	35-1.	Transmitter-receiver isolation test setup.	35-5
	35-2.	Transmitter-receiver isolation data sheet.	35-6
	36-1.	Radio interface parameters	36-5
	36-2.	System parameters.	36-6
	36-3.	Transmitter output power and antenna system reflected power test setup	36-7
	36-4.	Transmitter power output and VSWR data sheet . . .	36-8
	37-1.	Transmitter modulator frequency deviation (MLA) delay and linearity test setup	37-7
	37-2.	Transmitter modulator frequency deviation and linearity data sheet	37-8
	37-3.	Carrier dropout test setup	37-9
	37-4.	Typical delay and linearity curves	37-12
	37-5.	Transmitter modulator frequency deviation (graph) data sheet	37-13
	38-1.	Demodulator alinement verification test setup. . .	38-4
	38-2.	Demodulator linearity test setup	38-5
	39-1.	Transmitter frequency accuracy and stability (manual) test setup.	39-6
	39-2.	Typical temperature-humidity curve	39-7
	39-3.	Transmitter frequency accuracy and stability (automatic) test setup	39-8
	40-1.	Orderwire subcarrier deviation test setup.	40-3
	40-2.	Orderwire subcarrier performance data sheet. . . .	40-4
	40-3.	FM subcarrier demodulator test setup	40-5
	41-1.	RF amplifier test setup.	41-5
	41-2.	Typical frequency response (RF/IF) curves.	41-6
	41-3.	RF amplifier power gain test setup	41-7
	42-1.	Receiver AFC test setup.	42-4
	42-2.	Receiver AFC data sheet.	42-5
	43-1.	Typical phase-locked oscillator (AN/FRC-( )) . . .	43-4
	43-2.	Transmitter AFC test setup	43-5
	44-1.	Transmitter power gain and bandwidth test setup. .	44-5
	44-2.	AN/FRC-( ) performance characteristics (tentative).	44-6
	44-3.	Typical response of RF filters	44-7
	44-4.	Typical block diagrams of the AN/FRC-( )	44-8
	45-1.	Typical receiver discriminator and bandpass curves.	45-7
	45-2.	IF bandwidth response test setup	45-8
	45-3.	Receiver IF bandwidth data sheet	45-9
	45-4.	Receiver IF performance data sheet	45-10
	45-5.	Receiver IF amplifier gain test setup.	45-11
	45-6.	Receiver discriminator test setup.	45-12
	45-7.	Receiver discriminator alternate test setup. . . .	45-13
	45-8.	Typical performance characteristics of the AN/FRC-( ).	45-14

Page

Figure 46-1. Simplfied data recovery eye pattern. 46-3
46-2. Receiver phasing test setup. 46-4
46-3. Typical eye patterns for the AN/FRC-( ). 46-5
46-4. Typical eye pattern with phase difference. 46-6
47-1. Test tone variation (AN/FRC-162) test setup. . . . 47-5
47-2. Power requirements verification data sheet 47-6
48-1. Input power (AN/FRC-( )) test setup. 48-6
48-2. Digital radio input power and performance data sheet 48-7
49-1. Radio receiver-transmitter transient protection test setup. 49-5
49-2. Voltage variations test setup. 49-6
49-3. Transient protection data sheet. 49-7
49-4. DC spike test fixture. 49-8
49-5. Frequency transient test fixture 49-9
50-1. Reverse polarity test setup. 50-3
50-2. Reverse polarity data sheet. 50-4
51-1. Power supply protection test setup 51-4
51-2. Power supply protection data sheet 51-5
52-1. BER test setup using pattern generator and error detector (AN/FRC-162). 52-4
52-2. BER test setup using digital multiplex (AN/FRC-162) 52-5
52-3. Typical RSL vs AGC voltage curve (AN/FRC-162). . . 52-6
52-4. *BER (AN/FRC-162) data sheet.* 52-7
53-1. Cable interface test setup (AN/FRC-( )). 53-3
54-1. Back-to-back (AN/FRC-162) test setup 54-4
55-1. SCBS interface test setup. 55-3
56-1. Transmitter timing output test setup 56-6
56-2. Transmitter timing output accuracy and stability data sheet 56-7
56-3. Transmitter frequency accuracy test setup. 56-8
56-4. Temperature and humidity profile (MIL-STD-810C). . 56-9
57-1. Lockup and interface protection (radio) data sheet 57-4
57-2. AN/FRC-( ) inputs/outputs test setup 57-5
58-1. Signal performance monitor (RSL) test setup. . . . 58-6
58-2. Signal performance monitor data sheet. 58-7
58-3. Transmitter RF power output test setup 58-8
58-4. Test point impedance (bridge method) test setup. . 58-9
58-5. Frame error/impedance test setup 58-10
59-1. RF transmitter AFC test setup. 59-4
60-1. Modulator amplifier linearity and level adjustment test setup. 60-8
60-2. Modulator amplifier (27F2A-MW) 60-9
60-3. 2-GHz oscillator horizontal (62L2D-8MW). 60-10

			Page
Figure	60-4.	2-GHz oscillator deviation and linearity test setup	60-11
	60-5.	Baseband-to-RF linearity and delay test setup.	60-12
	61-1.	Receiver RF input vs AGC or IF voltage (calibration) test setup	61-5
	61-2.	Receiver RF input vs AGC or IF voltage (measurement) test setup	61-6
	62-1.	Receiver baseband linearity and group delay (IF to baseband) (AN/FRC-162) test setup	62-6
	62-2.	Receiver baseband linearity and group delay (RF to baseband) (AN/FRC-162) test setup	62-7
	63-1.	Typical block diagram of FASR equipment.	63-8
	63-2.	FASR equipment test setup.	63-9
	63-3.	FASR performance data sheet.	63-10
	64-1.	Data channel and multiplex/demultiplex input/output performance test setup.	64-11
	64-2.	Data channel and multiplex/demultiplex interface requirements data sheet.	64-12
	64-3.	Multiplex equipment self-check test setup.	64-13
	64-4.	Input/output interface test setup.	64-14
	65-1.	Test tone and customer levels data sheet	65-4
	65-2.	Typical test tone level (back-to-back) test setup.	65-5
	65-3.	Test tone and customer levels (AN/FRC-162 and VICOM 4000-2 system) (link) test setup	65-6
	66-1.	Insertion loss vs frequency limits (TD-1192)	66-7
	66-2.	Insertion loss vs frequency (automatic method) (calibration).	66-8
	66-3.	Insertion loss vs frequency (TSEC/CY-104, TD-1192, TD-1193, or VICOM 4000-2) test setup.	66-9
	66-4.	Insertion loss vs frequency (TDM/PCM) test setup	66-10
	66-5.	Insertion loss vs frequency (automatic method) test setup.	66-11
	67-1.	Voice channel frequency response (calibration)	67-5
	67-2.	Voice channel frequency response test setup.	67-6
	67-3.	Voice channel frequency response (with holding tone) test setup	67-7
	68-1.	Test point designations.	68-5
	68-2.	Idle voice channel circuit noise (manual) test setup.	68-6
	68-3.	Channel noise performance data sheet	68-7
	69-1.	Idle channel impulse noise test setup.	69-4
	69-2.	Idle channel impulse noise data sheet.	69-5
	70-1.	Voice channel crosstalk data sheet	70-9
	70-2.	Voice channel crosstalk (transmit) test setup.	70-10
	70-3.	Voice channel crosstalk (receive) test setup	70-11
	70-4.	Voice channel crosstalk (combined transmit and receive) test setup.	70-12

Page

Figure 70-5. Adjacent channel crosstalk (TSEC/CY-104) test setup 70-13
70-6. Voice channel crosstalk (AN/FCC-98) test setup 70-14
71-1. Voice channel envelope delay (end-to-end) (automatic) test setup 71-7
71-2. Voice channel envelope delay (end-to-end with return reference) (automatic) test setup. . . 71-8
71-3. Voice channel envelope delay (end-to-end with forward reference) (automatic) test setup . . 71-9
72-1. Voice channel envelope delay (end-to-end) (manual) test setup. 72-6
72-2. Voice channel envelope delay (end-to-end with return reference) (manual) test setup. 72-7
72-3. Voice channel envelope delay (end-to-end with forward reference) (manual) test setup 72-8
73-1. Voice channel intermodulation distortion test setup using a nonlinear distortion test set . 73-5
73-2. Voice channel intermodulation distortion test setup using test oscillators 73-6
73-3. Voice channel nonlinear distortion data sheet. . . 73-7
73-4. Graph for adding signals expressed in dB 73-8
73-5. Conversion of dB distortion to percent distortion 73-9
74-1. Harmonic distortion data sheet 74-5
74-2. Voice channel harmonic distortion test setup . . . 74-6
75-1. Circuit noise and single tone interference (calibration) 75-5
75-2. Circuit noise and single tone interference test setup. 75-6
76-1. Voice channel E&M signaling test setup 76-7
76-2. VF channel signaling data sheet. 76-8
76-3. Voice channel loopback and on-line test setup. . . 76-9
77-1. Multiplex (TD-1192) loopback and loopback alarm test setup. 77-5
77-2. Multiplex loop and carrier group alarm data sheet. 77-6
77-3. Multiplex (TD-1193) loopback and loopback alarm test setup. 77-7
78-1. Carrier group alarm test setup 78-5
79-1. Signal-to-noise quantizing data sheet. 79-8
79-2. Signal-to-noise quantizing (AN/FRC-162 and VICOM 4000-2 back-to-back) test setup. 79-9
79-3. Alternate signal-to-noise quantizing test setup. . 79-10
79-4. Signal-to-noise quantizing test setup using BITE (AN/FCC-98) 79-11
79-5. Signal-to-noise quantizing (AN/FCC-98) test setup 79-12

			Page
Figure	79-6.	Signal-to-noise quantizing end-to-end test setup .	79-13
	80-1.	Multiplex terminal end-to-end compatibility test setup	80-9
	80-2.	Typical envelope delay vs frequency curve (D2 channel bank).	80-10
	81-1.	Voice frequency channel impedance data sheet . . .	81-5
	81-2.	Voice frequency channel impedance (automatic method) test setup.	81-6
	82-1.	Voice frequency channel impedance (primary method) test setup.	82-5
	82-2.	Voice frequency channel impedance (alternate method) test setup.	82-6
	83-1.	Impedance measurements (bridge method) test setup	83-4
	84-1.	Voice frequency channel input/output interface (link) test setup.	84-4
	84-2.	Voice frequency channel input/output interface (loop) test setup.	84-5
	84-3.	Voice frequency channel input/output interface data sheet	84-6
	85-1.	VF channel input/output linearity data sheet . . .	85-4
	86-1.	Voice frequency channel level stability test setup	86-5
	86-2.	Voice frequency channel level stability (programmable calculator) test setup	86-6
	86-3.	Test tone stability data sheet	86-7
	87-1.	Balanced circuit between two line transformers . .	87-6
	87-2.	Voice channel longitudinal balance data sheet. . .	87-7
	87-3.	Voice frequency channel longitudinal balance (test set) test setup.	87-8
	87-4.	Voice frequency channel longitudinal balance (conventional) test setup.	87-9
	87-5.	Voice frequency channel longitudinal balance (alternate) test setup	87-10
	87-6.	Voice frequency channel output (receiving) longitudinal balance test setup.	87-11
	87-7.	Voice frequency channel longitudinal balance (balanced transformer network) test setup.	87-12
	87-8.	Voice frequency channel longitudinal balance (resistive network) test setup	87-13
	88-1.	Data error rate data sheet	88-5
	88-2.	Voice frequency channel BER (level verification) test setup.	88-6
	88-3.	Voice frequency channel BER (measurement) test setup.	88-7
	89-1.	TD-1192 (AN/FCC-98) BER and BCI test setup	89-8

Page

Figure 89-2. TD-1192 (AN/FCC-98) BER and BCI test setup using extender board. 89-9
89-3. Data error rate (multiplex) data sheet 89-10
90-1. Asynchronous data module (0 to 20 kb/s) test setup. 90-4
90-2. Asynchronous data module (50 kb/s) test setup. . . 90-5
90-3. Multirate data module test setup 90-6
90-4. Multirate data module (simultaneous transmit and receive) test setup 90-7
91-1. BER test setup (VICOM 4000-2). 91-6
91-2. BCI test setup (VICOM 4000-2). 91-7
92-1. Strapping options at data ports. 92-6
92-2. BER and BCI of 2d level multiplex (BITE) test setup. 92-7
92-3. BER and BCI of 2d level multiplex (external test equipment) test setup 92-8
93-1. Digital transmission system BER test setup 93-6
93-2. Digital transmission system BER (AN/FRC-162) test setup. 93-7
94-1. System data channel and timing jitter data sheet 94-5
94-2. System data channel and timing jitter test setup 94-6
95-1. Multiplex terminal timing accuracy and stability test setup 95-10
96-1. Bipolar and NRZ data channel port input/output impedances (comparison method) test setup. 96-7
96-2. Multiplex input/output impedance data sheet. . . . 96-8
96-3. Bipolar and NRZ data channel port input/output impedances (bridge method) test setup. 96-9
96-4. Bipolar and NRZ data channel port input/output impedances (oscilloscope method) test setup. . . . 96-10
97-1. Multiplex input/output voltage levels test setup. 97-5
97-2. Multiplex input/output voltage and performance level data sheet 97-6
98-1. Efficiently digitally linearizable coder threshold levels and step sizes (normalize to 8159). 98-7
98-2. PCM format test setup. 98-8
98-3. Coder/decoder performance data sheet 98-9
98-4. Code type and level test setup 98-13
98-5. Code level stability test setup. 98-14
99-1. Data/timing phase relationship 99-4
99-2. Digital data rise and fall times test setup. . . . 99-5
99-3. Digital data rise and fall times data sheet. . . . 99-6
100-1. Typical output pulse (AT&T D3 channel bank). . . . 100-4

		Page
Figure 100-2.	Data, timing, and pulse ringing test setups. . . .	100-5
100-3.	Data and timing signal ringing data sheet.	100-6
101-1.	Frame synchronization and reacquisition time test setup.	101-4
101-2.	Loss of frame and reacquisition time data sheet. .	101-5
102-1.	Typical waveforms of phasing (data and timing relationship -- trailing edge)	102-4
102-2.	Phasing (PCM data and timing) test setup	102-5
102-3.	Data and timing phasing and sampling data sheet. .	102-6
102-4.	Sampling internal test setup	102-7
103-1.	External timing source and receive timing output test setup	103-4
103-2.	External/internal timing frequency data sheet. . .	103-5
104-1.	Combined effects of jitter test setup.	104-3
104-2.	Combined effects of jitter data sheet.	104-4
105-1.	Typical alarm indicators (TD-1193)	105-6
105-2.	Monitor and alarm functions (AN/FCC-98).	105-7
105-3.	TD-1192 (AN/FCC-98) and TD-1193 monitor and alarms test setup.	105-8
105-4.	Multiplex alarm functions data sheet	105-9
106-1.	VICOM 4000-2 link protection test setup.	106-10
106-2.	Typical alarm flow diagram for multiplex	106-11
106-3.	Monitor and alarm operation (VICOM 4000-2/CY-104) data sheet	106-12
106-4.	CY-104 alarm operation test setup.	106-13
107-1.	TD-1192 (BITE) data function test setup.	107-7
107-2.	BITE performance data sheet.	107-8
107-3.	TD-1193 (BITE) test setup and facing layout. . . .	107-9
108-1.	50-kb/s data channel test setup.	108-6
108-2.	50-kb/s data channel performance data sheet. . . .	108-7
109-1.	Lockukp and interface protection (multiplex) test setup	109-4
109-2.	Lockup and interface protection (multiplex) data sheet	109-5
110-1.	Tandem test setup.	110-6
110-2.	TDM MBS interface test setup	110-7
110-3.	TDM interface and performance data sheet	110-8
111-1.	Multiplex/demultiplex input power test setup . . .	111-4
111-2.	Power input characteristics data sheet	111-5
112-1.	Battery plant data sheet	112-4
112-2.	Typical discharge curve of Load current at 77°F to final voltage per cell of 1.75 (24 cells)	112-5
113-1.	DC/AC inverter power subsystem data sheet.	113-7
113-2.	Rectifier-charger power subsystem data sheet . . .	113-8
113-3.	DC/AC inverter test setup.	113-12

Page

Figure 113-4. DC power system test setup 113-13
114-1. Idle channel noise recording test setup. 114-14
114-2. Idle channel noise recording data sheet. 114-15
114-3. Voice channel phase jitter recording test setup. . 114-16
114-4. Phase jitter and phase hits recording data sheet 114-17
114-5. Signal-to-noise quantizing recording test setup. . 114-18
114-6. BER recording test setup 114-19
114-7. RSL recording test setup 114-20
114-8. Probability distribution stroke chart (RSL) data sheet 114-21
114-9. Miscellaneous recording parameters 114-22
115-1. Earth resistance test setup. 115-7
115-2. Typical plot of megger resistance vs electrode distance. 115-8
115-3. Station ground data sheet. 115-9
115-4. Grounding data sheet 115-10
115-5. Grounding worksheet. 115-11
115-6. Ripple and wideband noise test setup 115-12
115-7. Typical AC fault locator and outlets 115-13

LIST OF TABLES

Table 1-1. Tests to be Performed. 1-2
5-1. Return Loss, VSWR, and Reflection Coefficient Conversion 5-6
9-1. Group Delay Calibration Factor 9-1
10-1. RF Interface BER Performance Levels 10-6
15-1. Total MBS Rates 15-2
15-2. Mission Bit Stream Rates 15-2
15-3. Radio Interface Data 15-4
15-4. TDM Data Rate. 15-7
29-1. Performance Parameters for LOS Digital Microwave Transmission 29-2
29-2. Small Signal Performance 29-2
29-3. Tranmitted Bandwidths (MHz). 29-2
29-4. Small Signal Performance (Level I) 29-4
29-5. Small Signal Performance (Level II). 29-5
33-1. Example of Monitored Functions 33-9
34-1. External Relay Contacts, AN/FRC-162 Radio. 34-7
34-2. Remote Control Functions 34-8
36-1. Power Output 36-2
37-1. Values of Modulation Index for which Carrier or Sidebands Have Zero Amplitude 37-10
39-1. Operating Conditions (AN/FRC-162). 39-2
39-2. Operating Conditions (AN/FRC-( )). 39-2

			Page
Table	48-1.	General Characteristics (AN/FRC-( ))	48-4
	63-1.	FASR Characteristics	63-4
	63-2.	Fault Alarm Simulation (Back-to-Back)	63-6
	63-3.	Typical FASR Monitor Functions and Simulated Faults	63-7
	64-1.	Input/Output Characteristics of Converter CV-3034	64-6
	64-2.	Equipment Interface Characteristics	64-8
	64-3.	Data Channel Interleaving Capability	64-3
	66-1.	Insertion Loss and Gain vs Frequency	66-6
	70-1.	Possible Crosstalk Channel Configuration	70-8
	75-1.	Noise Unit Conversion Chart	75-4
	79-1.	Signal-to-Noise Quantizing Ratio	79-2
	80-1.	D3 Channel Bank Electrical Input/Output Requirements	80-3
	80-2.	D2 Channel Bank Electrical Requirements	80-4
	80-3.	D3 Channel Bank Transmission Requirements	80-5
	80-4.	D2 Channel Bank Transmission Requirements	80-7
	81-1.	Voice Frequency Channel Impedance Deviations	81-4
	83-1.	Test Tone Guide for Voltmeter	83-3
	89-1.	Maximum Number of Data Channels	89-5
	89-2.	Channel Operational Switch Settings	89-5
	89-3.	Outgoing Group Alarm Strapping	89-5
	89-4.	Bit Stream (24-Channel Digital Timing Generator (DTG)) Strapping	89-6
	89-5.	Zero-Suppression (24-Channel DTG) Strapping	89-6
	89-6.	50-kb/s Data Module Strapping	89-6
	89-7.	Multirate Data Module Clock Source Strapping	89-6
	89-8.	Multirate Data Module Switch Options	89-7
	90-1.	50-kb/s Data Module Strapping	90-2
	91-1.	Bit Error Rate vs SNR	91-4
	92-1.	Digital Characteristics, TD-1193 vs Port Options	92-2
	95-1.	TD-1192 (AN/FCC-98) Timing and Signal Characteristics	95-2
	95-2.	TD-1192 (AN/FCC-98) Environmental Operating Parameters	95-3
	95-3.	TD-1193 TDM MBS Characteristics	95-4
	98-1.	Folded Binary Code Structure Segment Points	98-6
	100-1.	AT&T D3 Channel Bank Pulse Characteristics	100-1
	101-1.	Mission Bit Stream Characteristics	101-2
	105-1.	TD-1192 (AN/FCC-98) Monitor and Alarms	105-10
	105-2.	TD-1193 Monitor and Alarm Functions	105-11
	110-1.	TDM Data Port Input Tolerance	110-2
	110-2.	Combined Input vs Corresponding MBS Rate	110-2
	112-1.	Station Battery Design Data	112-3

Page

Table 113-1. Technical Characteristics of DC/AC Inverter Used in the AN/FRC-162 and VICOM 4000-2 System. 113-9
113-2. Technical Characteristics of DC Power, Rectifiers, and Chargers Used in the AN/FRC-162 and VICOM 4000-2 System 113-10
115-1. Guide of Location of Reference Ground Rods 115-3

CHAPTER 1

INTRODUCTION

1-1. GENERAL.

a. The procedures contained in this pamphlet are designed as a guide to standardize the test techniques, data recording, and documentation during a quality assurance evaluation in accordance with DCA Circular (DCAC) 310-70-57, test and acceptance procedures in accordance with CCR 702-1-2, and onsite quality control testing in accordance with CCR 702-1-3.

b. The specific tests that are to be performed will normally be included in the standard engineering plan, test and acceptance plan, test notification message (figs. A-2 and A-3, CCR 702-1-3) or contract specifications for the systems, terminals, and/or equipment to be evaluated. These procedures may be modified or supplemented by the team chief or the onsite noncommissioned officer in charge (NCOIC), as required, as long as the required data elements remain essentially unchanged.

c. These tests may be performed during acceptance testing of contractor engineered, furnished, and installed (EF&I) systems to ensure that the systems conform to contract specifications or other applicable documents. They may also be used by installer or quality assurance personnel during onsite testing as directed.

d. It is recognized that all tests contained in this pamphlet may not be required in every case; however, they have been included so as to provide as complete a test sequence as possible (table 1-1).

1-2. APPLICABILITY. These procedures are applicable to all US Army Communications Command (USACC) activities engaged in testing and evaluating communications systems, subsystems, and equipment.

1-3. SCOPE. This pamphlet contains the basic test procedures, test equipment configurations, specifications, and data recording requirements for the digital radio, multiplex, and associated circuits. The majority of the tests are directly applicable to the existing system in the European area.

1-4. DISCUSSION.

a. The specifications for the individual tests have been extracted from the technical manual on the equipment, applicable military standards, contract Communications-Electronics Engineering Installation Agency (CEEIA) specifications, and Defense Communications Agency (DCA) publications, where applicable. Personnel should consult the system performance parameters as contained in the standard engineering package, contract specifications, and other pertinent literature before testing to determine the applicable specification.

b. Test equipment listed in appendix A is based on the USACC Preferred Items List (PIL) as contained in CCP 750-2. If the specified equipment is not

Table 1-1. Tests To Be Performed

TEST NUMBER	T&A	TEP	O&M	REMARKS
DT-200				
DT-201				
DT-202				
DT-203				
DT-204				
DT-205				
DT-206				
DT-207				
DT-208				
DT-209				
DT-210				
DT-211				
DT-212				
DT-213				
DT-214				
DT-215				
DT-216				
DT-217				
DT-218				
DT-219				
DT-209				TO BE DETERMINED
DT-220				
DT-221				
DT-222				
DT-223				
DT-224				
DT-225				
DT-226				
DT-227				
DT-228				
DT-229				
DT-230				
DT-231				
DT-232				
DT-233				
DT-234				
DT-235				
DT-236				
DT-237				
DT-238				
DT-239				
DT-249				
DT-250				
DT-251				

Table 1-1. Tests To Be Performed (Continued)

TEST NUMBER	T&A	TEP	O&M	REMARKS
DT-252				
DT-253				
DT-254				
DT-255				
DT-256				
DT-257				
DT-258				
DT-259				
DT-260				
DT-261				
DT-262				
DT-263				
DT-264				
DT-265				
DT-266				
DT-267				
DT-268				
DT-269				
DT-269				
DT-270				
DT-271				TO BE DETERMINED
DT-272				
DT-273				
DT-274				
DT-275				
DT-276				
DT-277				
DT-278				
DT-279				
DT-280				
DT-281				
DT-282				
DT-283				
DT-284				
DT-285				
DT-286				
DT-287				
DT-288				
DT-289				
DT-289				
DT-290				
DT-300				
DT-301				
DT-302				

Table 1-1. Tests To Be Performed (Continued)

TEST NUMBER	T&A	TEP	O&M	REMARKS
DT-303 DT-304 DT-305 DT-306 DT-307 DT-308 DT-309 DT-310 DT-311 DT-312				TO BE DETERMINED

available, substitutes may be used as long as the same degree of accuracy is maintained. In addition to the items shown in appendix A, such items as connectors, cables, etc., will also be required depending on the particular application of the procedures.

c. The individual procedures contain sample data sheets for recording all required test data. The test data will be transcribed onto the forms as the testing progresses and the measured test results analyzed to assure that the test data accurately reflects the performance characteristics of the system, subsystem, or equipment being evaluated. Entries will be typed or printed on the data sheets to ensure that they are legible. Further, all data elements will be checked for completeness, accuracy, neatness, and validity before the test engineer or technician signs the data sheet. The information provided on the data sheets will be used for the final test report; therefore, the entries must provide a quality product when reproduced.

d. Selected tutorial information, as appropriate, has been included in the individual procedures to aid in their understanding and application by test personnel. As the procedures are used, they will require changes or additions to accommodate new systems, subsystems, and/or equipment; therefore, this document is designed so that changes can be incorporated without a major revision.

e. These procedures are in consonance with the DCA requirement as specified in paragraph 3e, chapter 2, DCAC 310-70-57.

f. This pamphlet includes tests to evaluate the performance of the voice frequency channels, radio systems, multiplex equipment, and the antenna system. The test procedures apply primarily to digital radio, digital multiplex, and voice processing equipment. Implementation of fully digital systems may require revision of these procedures within the CY 79 time frame. Three types of digital links currently in use are:

(1) *Link Type 1--Voice Channel Breakout to Voice Channel Breakout (300 to 3000 Hz).* Since each end of this type link includes radio, multiplex, and voice channels, all tests can be accomplished.

(2) *Link Type 2--Voice Channel Breakout to 2d Level Multiplex (1.544 megabits per second (mb/s)).* Since one end of this type link does not contain voice channel breakouts, all of the over-the-link voice channel tests cannot be made unless the links are extended in tandem to the next voice breakout. Certain voice channel tests such as impedance and crosstalk can be accomplished in part or completely.

(3) *Link Type 3--2d Level Multiplex to 2d Level Multiplex (1.544 mb/s).* This type link will permit only testing of the multiplex and radio.

g. The present system uses pulse code modulation (PCM) with time division multiplex (TDM) whose baseband is a serial data stream of 12.6 mb/s in the

format of three-level, partial-response. The radio will be a standard Defense Communications System (DCS) microwave frequency modulation (FM) radio with modifications.

1-5. TESTING PHILOSOPHY.

a. General.

(1) A logical test sequence must be followed during the evaluation since the results of one particular test may impact on one or more succeeding test sequences. The test sequence may be divided into three elements; that is, testing of individual items of equipment; testing of a subsystem; and finally, a complete systems test.

(2) Equipment testing can be defined as that testing required to determine if a particular piece of equipment is performing within its design specifications. Those items of equipment found to be deficient should be repaired or adjusted as required to bring equipment performance within specifications. This is necessary since peak operational performance is required to ensure that system performance parameters are within specifications. In other words, deficiencies in individual pieces of equipment that are left uncorrected may impact on the service being provided to the customer.

(3) As the satisfactory testing of individual items of equipment progresses, subsystems will gradually evolve. A subsystem is that grouping of equipment designed to perform as a functional part of the complete system. Assuming individual items of equipment have been proved to be within specifications, the subsystem testing will determine how well the items perform when combined into a subsystem. During this phase of testing, emphasis should be placed on functional performance rather than the performance of individual pieces of equipment. This phase should reveal any unusual problems with interfacing of equipment to form a subsystem. Such things as level incompatibility and impedance mismatches should be evident during subsystem testing.

(4) System testing consists of those test techniques required to evaluate the individual items of equipment and the subsystem's performance when installed as a complete system. Tests for the entire system should be designed to determine the ability of the system to meet its overall design specifications. The system tests must consider the desired system end product, encompass the functions of the subsystems, and yield an evaluation of the composite function of the system. The design of these tests will be predicated, to some degree, on the availability of equipment and facilities. The system tests on operational systems will also be limited due to operational requirements and availability of system downtime.

(5) In analog transmission systems, the key performance indicators are noise level and signal level. These are usually thought of in terms of signal-to-noise ratio (SNR). Noise is cumulative in these systems, so that any noise generated at any level or point in the system is passed on and added to that generated at any later point in the system. The noise level is considered a key performance indicator.

(6) In a digital transmission system, while noise is certainly important, it is not cumulative through the system in the same manner as in an analog system. An increase in noise level at the radio baseband level, for example, does not necessarily result in a corresponding increase in noise at the analog channel output. Cumulative noise is largely eliminated. However, when the noise is high enough to produce errors at any point, these, and any errors produced at successive points in the system, are cumulative. The key performance indicator, therefore, is digital error rate. This holds true down through the multiplexing hierarchy. However, the current digital systems include an analog/digital conversion in the form of PCM as an integral part of the transmission equipment. Therefore, analog channel measurements similar to those applicable to voice channels in an analog system are also applicable to voice channels in a digital system.

(7) A logical approach to the development of test procedures is to develop procedures for those measurements which indicate the performance and determine the available margin of performance of each major portion of the link; that is, the radio, multiplex, and the analog/digital conversion. Each of these primary performance tests should be designed with a specific objective, so that when all of the key performance tests are completed, the overall performance of the system is measured. If all the results of the primary performance tests are satisfactory, it can be reasonably assumed that the overall performance of the system is satisfactory. However, in the event one or more of the performance tests indicates unsatisfactory performance, there must be procedures included to permit some logical course of action to optimize the performance. Therefore, for each of the performance tests, there must be a series of tests designed to localize the poor performing component in the event the primary performance indicator is unsatisfactory. In this way, procedures would be available for any unforeseeable situation. However, the need to perform all procedures included in this document would be determined by the prevailing conditions and as specified by the team chief or the onsite NCOIC. In general, the test activity would perform, as a minimum, those tests and measurements identified as primary performance tests, plus those additional tests indicated by the results. While it is possible to determine a logical progression for the general case, the final determination of which additional tests are to be performed in any specific case will depend on the system engineering plan, contract specifications, or as required by the team chief or the onsite NCOIC.

(8) The digital transmission systems currently in use and those planned for the immediate future (before CY 79) will use a standard DCS microwave FM radio. The system design is based on proper operation of the radio as an FM system. Consequently, those tests used for the radio should be the same as those used currently to test the FM radio. In the current digital radios, the processing of digital signals for application to the FM radio is done external to the radio.

(9) As mentioned above, the key performance indicator for digital systems is digital error rate. This appears to be the significant difference between the testing of digital and analog systems. There are, of course, some other differences. For example, in testing voice channels derived in a TDM/PCM

system, certain precautions must be observed. The more significant differences are discussed below.

b. Error Rate Measurements.

(1) In the transmission of digital data from one data terminal to another, errors in the signals at the receiving terminal will affect the accuracy of the received data. However, it cannot be said that a given average error rate will have the same effect on the accuracy of the received data in all cases. The terminals generating and receiving the data signals process the data in different ways. This difference in the processing and use of the data signals must be considered in determining the effect of errors. For example, an error rate that would drastically affect the accuracy of data transferred from machine to machine, such as alphanumeric data communications between computers, may have no significant effect on a digitized speech transmission. Further, the distribution of the errors also affects not only the accuracy of the received information but, in some systems, the amount of data that can be transmitted (the data throughput) through the channel.

(2) The accuracy of the data received may also be affected by the distribution of errors. In the automated communications systems, the probability of undetected errors increases only slightly when the errors occur in large bursts (that is, when there are more errors per block). However, in some error detection or correction systems, the probability of undetected or uncorrected errors varies considerably with error distribution. An error correction system designed to correct randomly distributed errors is not necessarily capable of correcting large bursts, and conversely, most burst error correction systems are not ideal for the correction of randomly distributed errors.

(3) It can be concluded that in order to determine the effect of errors on a given data system it is necessary to know not only the number and distribution of the errors but the manner in which the data signals are processed as well. In considering errors in a transmission link that will be used to transmit digital signals for many different types of services, it is not practical to establish an optimum distribution of errors. In fact, for purposes of evaluating the transmission link, the measurement of error rate is adequate. Nevertheless, in measuring the errors on the transmission system, an effort should be made to obtain the distribution of the errors, particularly at those levels where digital channels are furnished to users. This data can then be used to estimate the capability of the system to provide a particular type of service.

(4) In measuring error rates in digital systems, it is desirable to measure at all levels; that is, at the baseband level (12.6 mb/s). In the current systems it may not be practical to measure at the baseband level since there is no access to the baseband non-return-to-zero (NRZ) signal without changing internal connections in the equipment. In addition, suitable test equipment may not be available for interfacing at the baseband level. Since the error rate at the digroup (1.544 mb/s) level should be substantially the same as that at baseband level, a measurement at that level can be used instead to indicate the error performance. It will be necessary to perform additional

tests of the 2d level multiplexers to determine whether the problem is in the link or in the multiplex equipment.

(5) The digital error rate tests discussed above are intended to measure the performance of the system from the digital channel input to the output. There remain the analog channels which must be tested to determine their capability to meet the performance requirements. These requirements are the same as those specified for voice channels derived in a frequency division multiplex (FDM) system. However, as mentioned previously, there are some precautions that must be observed when measuring analog channels derived in a PCM/TDM system. The more significant of these are as follows:

(a) When certain frequencies, which are harmonically related to the sampling frequency (8000 Hz), are transmitted through a PCM channel, the distortion products fall at a few discrete frequencies within the band. These troublesome frequencies must be avoided when testing. Since several of these frequencies fall at multiples of 100 Hz and since it has been traditional to test voice channels at multiples of 1000 Hz, the general rule is to avoid exact multiples of 1000 Hz. Increasing the test frequency by about 4 Hz is sufficient to avoid the problem. Limiting the increase to about 20 Hz will preclude using another troublesome frequency which is not a multiple of 1000 Hz (1333 1/3 Hz). Therefore, the test frequencies should be set at multiples of 100 Hz plus 4 to 20 Hz (104 to 120 Hz, 204 to 220 Hz, 1004 to 1020 Hz). All voice channel testing procedures should be modified as appropriate to reflect this concept.

(b) In analog (FDM) systems, it has been traditional to measure the noise in an idle channel. The noise thus measured includes intermodulation products and crosstalk as well as thermal noise in the system and is a good indicator of the overall performance of the channel. In digital (PCM) systems, when the channel is idle, the low noise level normally present is not indicative of the noise level in the presence of a signal. Therefore, the measurement must be made with the channel activated. This is done using a notched noise measurement. In this procedure, a signal is sent over the channel at a frequency of 1004 to 1020 Hz and at the normal test tone level. At the receive end, a narrow rejection filter (notch filter) removes the test signal, and the remaining noise, which consists primarily of quantizing distortion, is measured. It is important that the test tone level used in the test be set to the proper value since the noise limits specified for the channel are based on operation of the channel at the correct signal levels. The PCM used in these systems is a nonlinear encoding process which is designed to provide a substantially constant SNR over the operating level range. It is apparent that the noise level should increase with signal level. In this connection, while the noise level should be measured with the correct signal level, additional noise measurements should be made with various signal levels to determine whether or not the PCM encoders are operating properly.

(c) Voice channel tests should be performed on as many channels as is practical. This pamphlet or the engineering package may stipulate the number of channels to be tested.

c. System Concept. From a system-oriented viewpoint and for tandem link performance, the noise contribution to the voice channel from all sources must be considered. Thus, it is necessary to include the channel noise contribution by the instation wiring and equipment. Factors, such as crosstalk, improper voice channel signal levels, phase jitter, delay distortion, and intermodulation distortion, can and do originate both within the radio-multiplex combination and the instation wiring and equipment. These factors strongly influence the tandem link performance and must be included in any channel performance measurement.

d. Test Point Definitions. In order to measure the above performance factors and to locate their origin, it is necessary to make measurements at the proper test points. The important voice channel test points in a radio link and station complex are shown in figures 1-1 and 1-2. These test points are located at the transmit and receive ends of the radio link, and their definitions and numbering system are given in figures 1-1 and 1-2. The voice frequency patch bay (VFPB) and the multiplex are usually hard-wired connected through the combined distribution frame and, therefore, are equivalent as test points, except for the possibility of induced signals in the connecting cable. These equivalent test points are designated as the transmit or receive VFPB test points. The radio frequency (RF) signal test points at the high frequency (HF) distribution are included in figures 1-1 and 1-2 for completeness. Present equipment installed in the 1st level multiplex can be used for back-to-back measurements or to measure noise, loss, crosstalk, etc., between the VFPB and the multiplex when required. Test points 5 and 8 are not shown on figures 1-1 and 1-2, but if used, data can be recorded on figure 1-3 (USACC Form 629-R).

NOTE: It should be noted that in most cases the signal level specified for digital multiplexers and radios is given in volts peak-to-peak (VPP). Therefore, an osilloscope will be required to measure these levels.

e. Measurement Test Points. The performance measurements are made on a segregated link basis, with one-half of the station technical control facility (TCF) at each end. Hence the complete station/link subsystem extends from the transmit primary patch bay (PPB) (TP-1) to the receive PPB (TP-12). This concept would not apply to those facilities having no audio breakout capability.

f. Test Point Jacks.

(1) The wide variety of names or titles used for the jacks on the various patch bays (line, equipment, drops, monitor, modulation in, modulation out) and the order in which these jacks are connected in the system make it impossible to provide explicit instructions relative to the particular jack to be used to obtain the proper termination points or the proper points to which a meter should be connected. Figures 1-1 and 1-2, the applicable diagrams in the test procedures, and the jackfield configuration and nomenclature used in the TCF of the station under test will be used as guides in determining the correct jack which must be used in order to ensure that the tested circuit is being terminated and metered at the proper points.

(2) The test points selected for digital systems are roughly compatible with those used in FDM systems. Test points 5 and 8 as reflected in figure 1-3 (USACC Form 629-R) and other data sheets are not used at this time. However, they may be used on future systems or on the existing system when tests are performed at the built-in test panel of the 1st level multiplex as outlined in paragraph 1-5d.

(3) Before beginning tests, the test point data should be obtained from the station technical data and recorded on figure 1-3 (USACC Form 629-R). This data will then be used as reference data for subsequent tests.

(4) Figure 1-4 shows a typical three-level, partial-response link performance setup while figure 1-5 shows a typical test arrangement for a multiplex bit error rate (BER) test. Figures 1-6 and 1-7 are typical diagrams of the existing AN/FCC-162 and AN/FCC-97 systems.

(5) Figure 1-8 shows a typical frequency diversity fully digitized radio while figure 1-9 shows a typical space diversity system.

1-6. SYSTEM MEASUREMENTS.

a. Correct measurement techniques are usually acquired through a combination of formal training and field experience. Extensive experience is not required, however, to avoid many of the mistakes commonly made by the test teams. Some of the most common mistakes are:

(1) Improper terminations, lack of a termination, or mismatched impedances are common errors which result in erroneous test data. The individual performing the tests will examine the data while the test is in progress to ensure that the results are valid. It is essential that the individual be familiar with the manufacturer's specifications and design standards to ascertain that the test data is within required parameters.

(2) Lack of adequate grounding, no ground at all, or ground loops will result in invalid test data. The station ground of the system being evaluated will be checked by the test teams before proceeding to the individual test sequences. This check should also include the potential between subsystems and adjacent equipment areas. The test leads used by the test team will be fabricated and used in such a manner as to preclude introducing unwanted ground loops. As an example, the test leads for the frequency selective voltmeter will be constructed so that 80- to 100-dB attenuation is provided for all frequencies and levels external to the systems being evaluated.

b. Technical manuals or manufacturer's literature will be consulted to obtain the test level points (TLP) and the impedance at the point at which the measurement is to be taken. This information will be entered on the appropriate data sheet to aid in the analysis process.

c. If the test data does not correlate with expected performance levels, the test will be rerun to ensure that the test techniques are valid or to isolate the cause for the disparity in measured performance versus the design specifications. This must be accomplished while the test team is onsite since it would not be cost-effective for the teams to rerun the test after departure from the terminal.

d. When measured results depart from the expected value, the test team will isolate the cause for the discrepancy and implement the necessary corrective action. Those areas not corrected while onsite must be identified as to the specific problem and recommended corrective action.

1-7. DATA RECORDING AND ANALYSIS. During all phases of the testing, personnel must exercise precautions as to TLP's, impedance matching, and test equipment configuration to assure that invalid test results are not attributed to an incorrect test equipment connection. An example of this would be connecting a meter with a 600-ohm input impedance into a 75-ohm TLP. This would result in a measurement error of approximately 9 dB. Similarly, improper grounding of the test instrumentation or improperly fabricated test leads can introduce noise into the equipment being evaluated, resulting in invalid test results.

1-8. REFERENCES.

a. DCAC 300-175-9, DCS Operating-Maintenance Electrical Performance Standards.

b. DCAC 310-70-57, DCS Quality Assurance Program.

c. DCAC 310-70-57, Supplement 1, Technical Evaluation Line-of-Sight (LOS) and Tropospheric Scatter Links.

d. DCSS-1-70(A), Amendment IV (Revised), DCS M/W Radio Digital Modification.

e. MIL-HDBK-411, Long Haul Communications (DCS) Power and Environmental Control for Physical Plant.

f. MIL-STD-188-100, Common Long Haul and Tactical Communication System Technical Standards.

g. MIL-STD-188-124, Grounding, Bonding, and Shielding for Long Haul/ Tactical Communications Systems.

h. MIL-STD-188-313, Subsystem Design and Engineering Standards and Equipment Technical Design Standards for Long Haul Communications Transversing Microwave LOS Radio and Tropospheric Scatter Radio.

i. MIL-STD-188-322, Subsystem Design/Engineering and Equipment Technical Design Standards for Long Haul Line-of-Sight (LOS) Digital Microwave Radio Transmission.

j. MIL-STD-461A, Electromagnetic Interference Characteristics Requirements for Equipment.

k. MIL-STD-462, Measurement of Electromagnetic Interference Characteristics.

l. MIL-STD-810C, Environmental Test Methods.

m. FM 11-490-9, Communications-Electronics Facilities: Grounding, Bonding, and Shielding.

n. TM 11-5805-688-14-1, Service and Maintenance Instructions: AN/GSC-24(V) Multiplexer Set.

o. TM 11-5805-711-12, Operator and Organizational Maintenance Manual: Organizational Maintenance, AN/FCC-98(V) Multiplexer Set (Preliminary).

p. CCR 702-1-2, USACC Quality Assurance Program for Engineering, Installation, and Acceptance of Communications-Electronics Equipment and Systems.

q. CCR 702-1-3, USACC Operational Quality Assurance Program for Communications-Electronics Systems and Facilities.

r. CCP 750-2, Test, Measurement, and Diagnostic Equipment Preferred Items List.

s. SCCC-73017, Specification for DCS Microwave Radio.

t. CCC-74047, Specification for Multiplexer/Demultiplexer TD-1192( ) (P)/F.

u. CCC-74048, Specification for Multiplexer/Demultiplexer TD-1193( )/F.

v. CCC-74049, Specification for Radio Set AN/FRC-( ).

w. Hewlett-Packard Application Note 77-4, Swept-Frequency Group Delay Measurements.

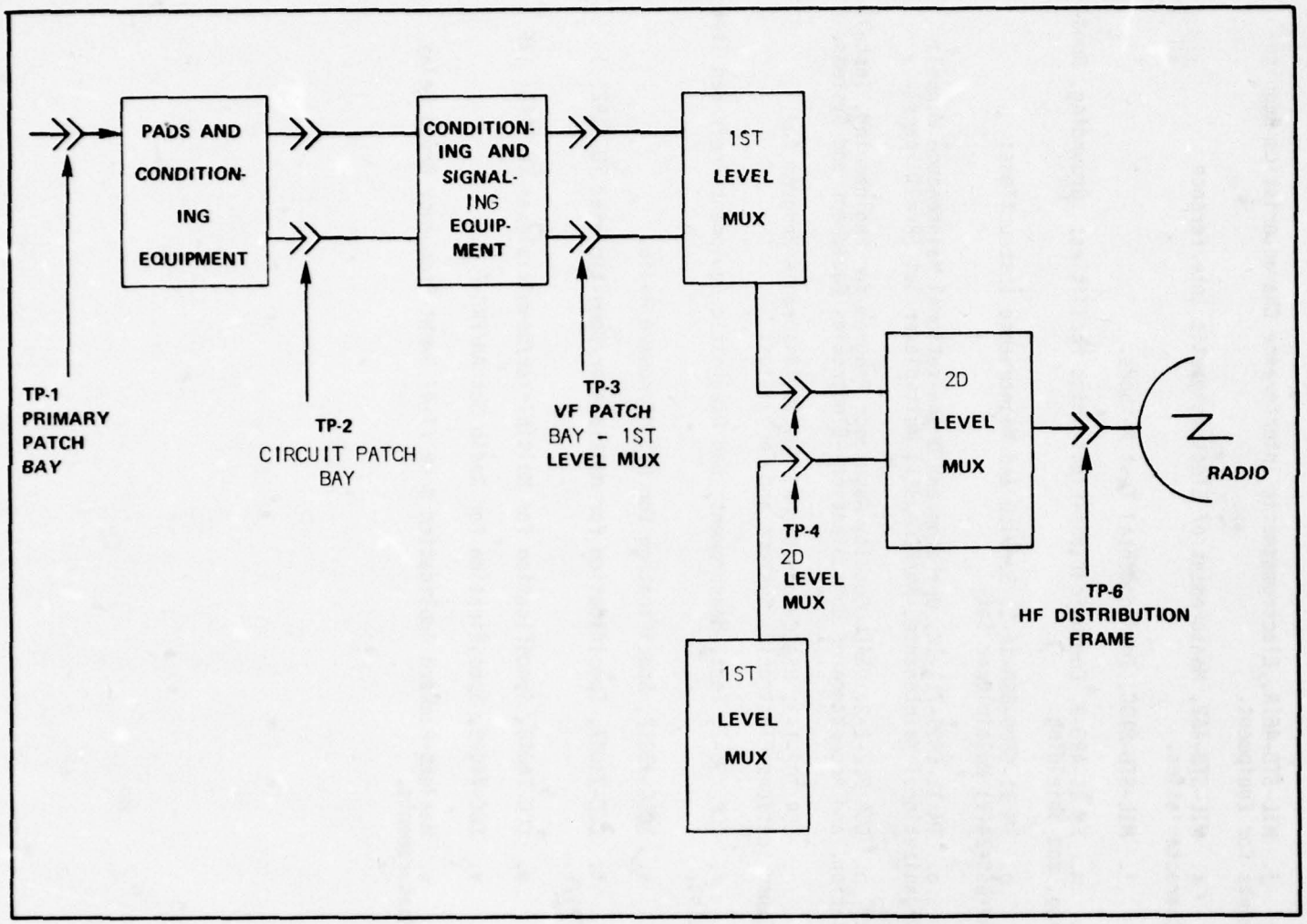


Figure 1-1. Typical test point designations (transmit).

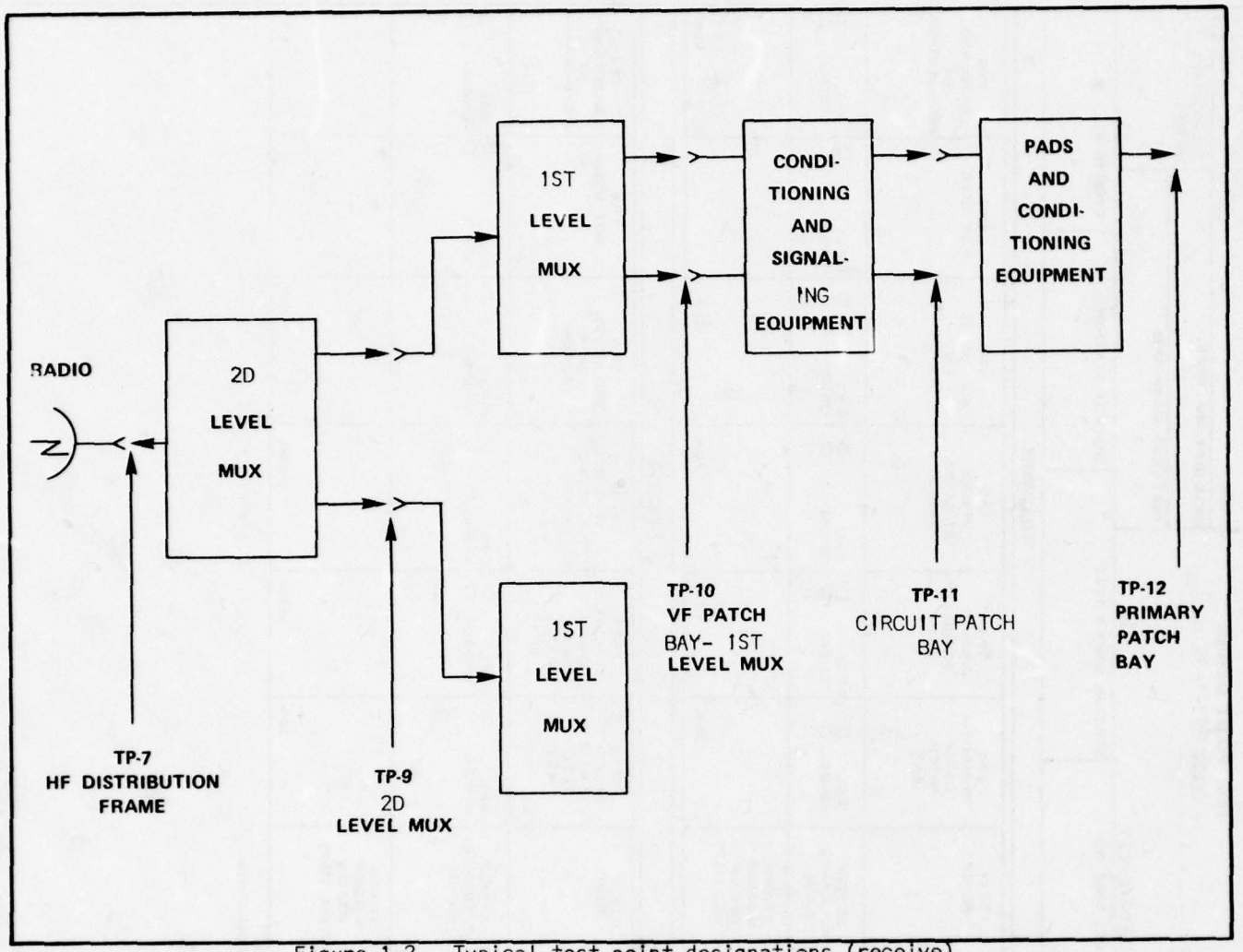


Figure 1-2. Typical test point designations (receive).

TEST POINT DESIGN (CCR 702-1-3) DATA SHEET	PAGE OF PAGES	
	DATE (DAY, MO., YEAR)	TECHNICIANS INITIAL
	TEST ENGR SIGNATURE	

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TYPE MUX

TRANSMIT

TEST POINT	TP-1 PRIMARY CABLE PATCH BAY	TP-2 CIRCUIT PATCH BAY	TP-3 VF MUX 1ST LEVEL PATCH	TP-4 2D LEVEL MUX PATCH	TP-5 NOT USED	TP-6 BASEBAND HF DISTRIBUTION
DESIGN IMPEDANCE OHMS	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω
TRANSMISSION DESIGN LEVEL (TLP)	dBm	dBm	dBm	VPP		VPP

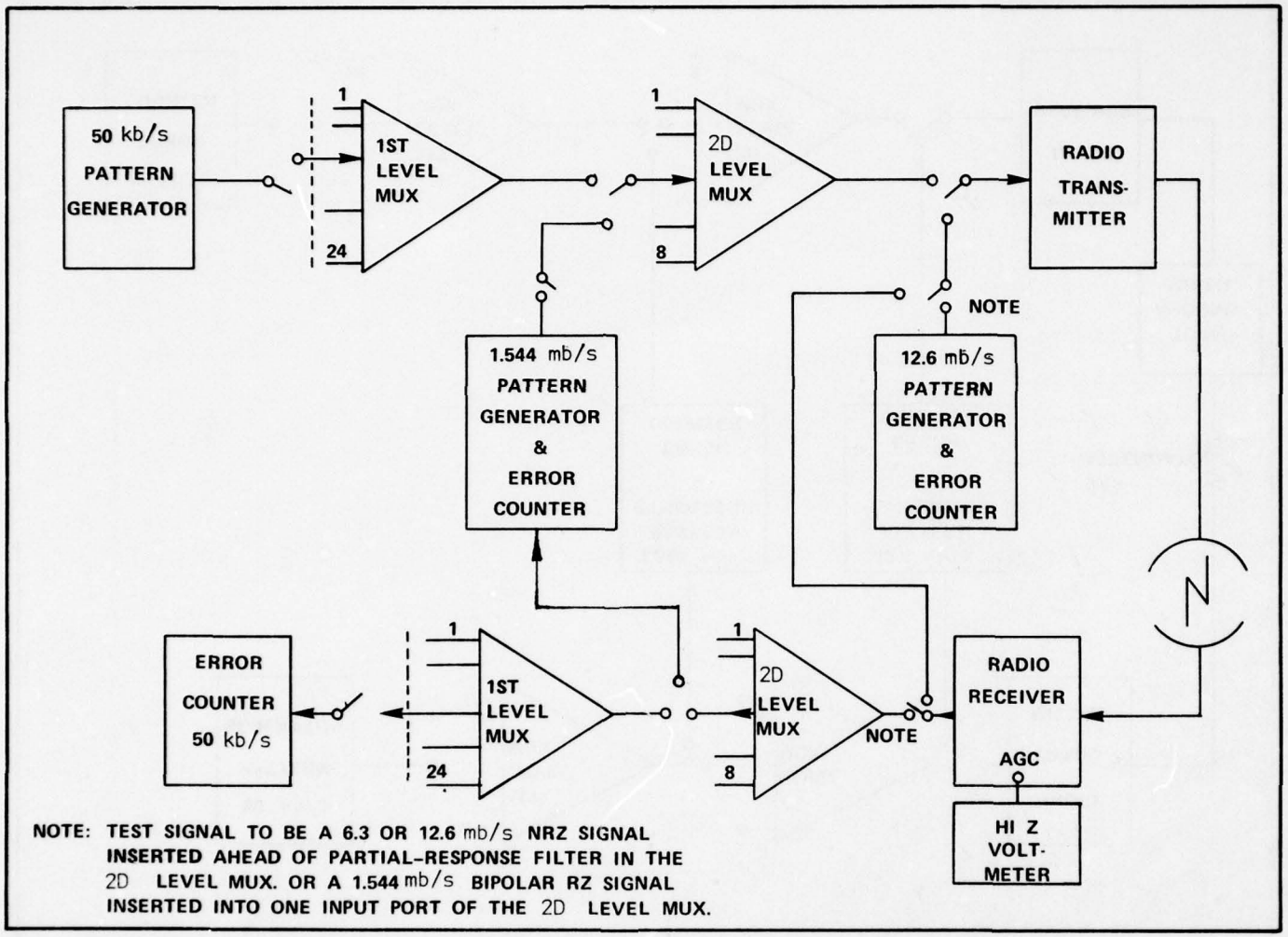
RECEIVE

TEST POINT	TP-12 PRIMARY CABLE PATCH BAY	TP-11 CIRCUIT EQUAL LEVEL PATCH BAY	TP-10 VF MUX 1ST LEVEL PATCH	TP-9 2ND LEVEL MUX PATCH	TP-8 NOT USED	TP-7 BASEBAND HF DISTRIBUTION
DESIGN IMPEDANCE OHMS	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω	BAL ☐ UNBAL ☐ Ω
TRANSMISSION DESIGN LEVEL (TLP)	dBm	dBm	dBm	VPP		VPP

COMMENTS

USACC FORM 629-R
1 MAY 79

Figure 1-3. Test point design data sheet.



CCP 702-11

Figure 1-4. Three-level, partial-response radio link bit error rate (BER) test setup.

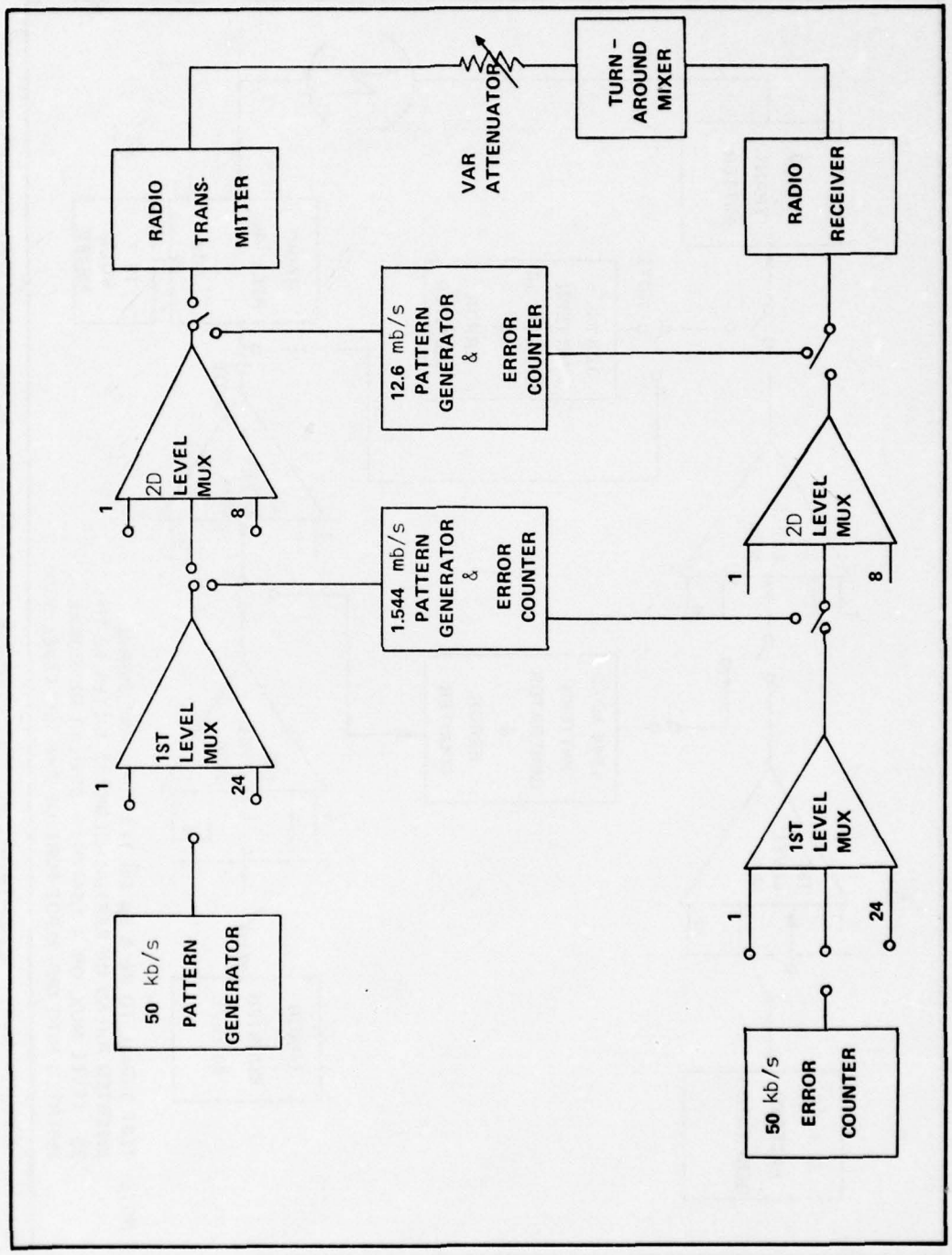


Figure 1-5. Typical back-to-back BER test setup.

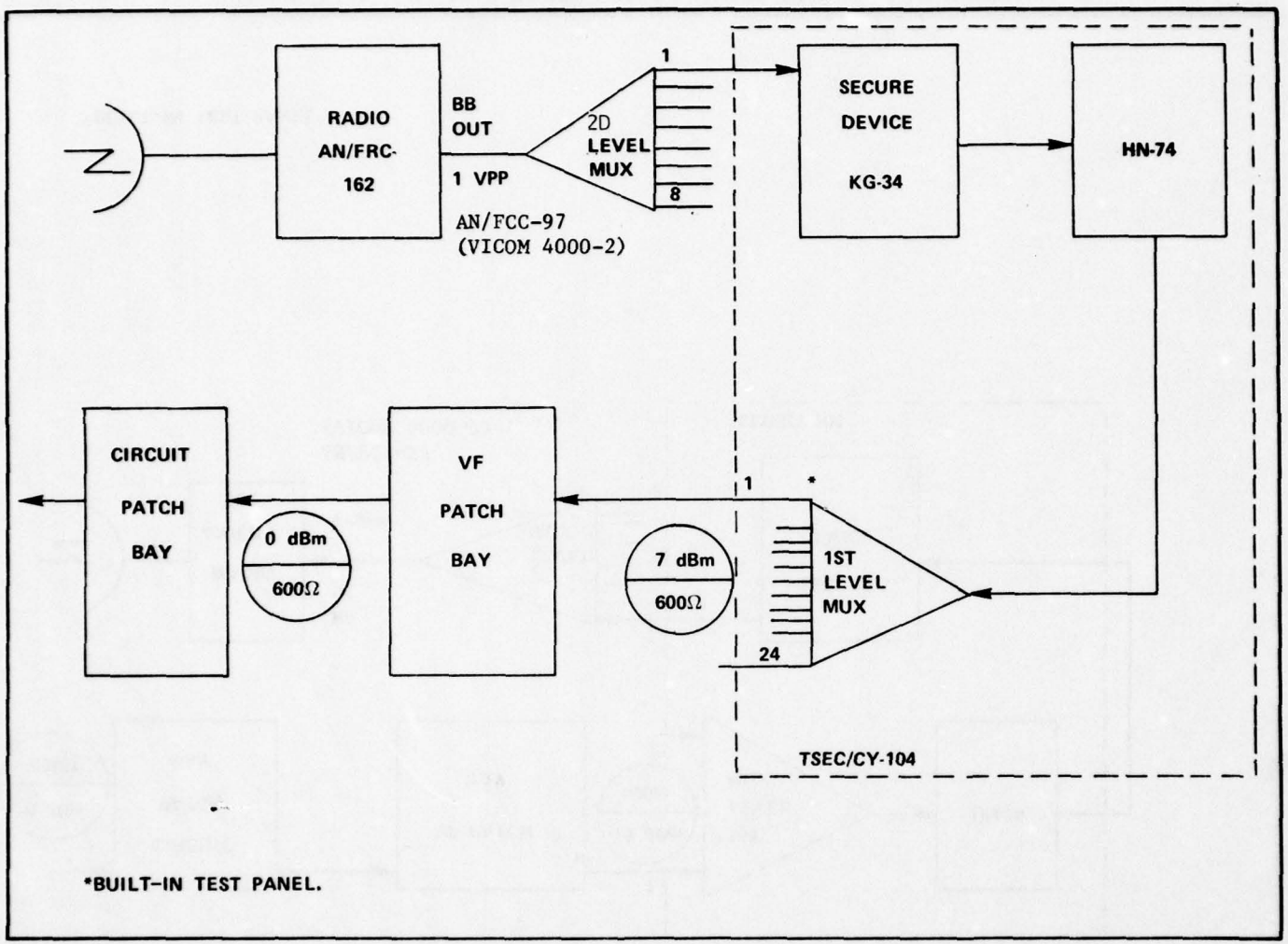


Figure 1-6. Typical AN/FRC-162 and AN/FCC-97 system (receive).

CCP 702-11

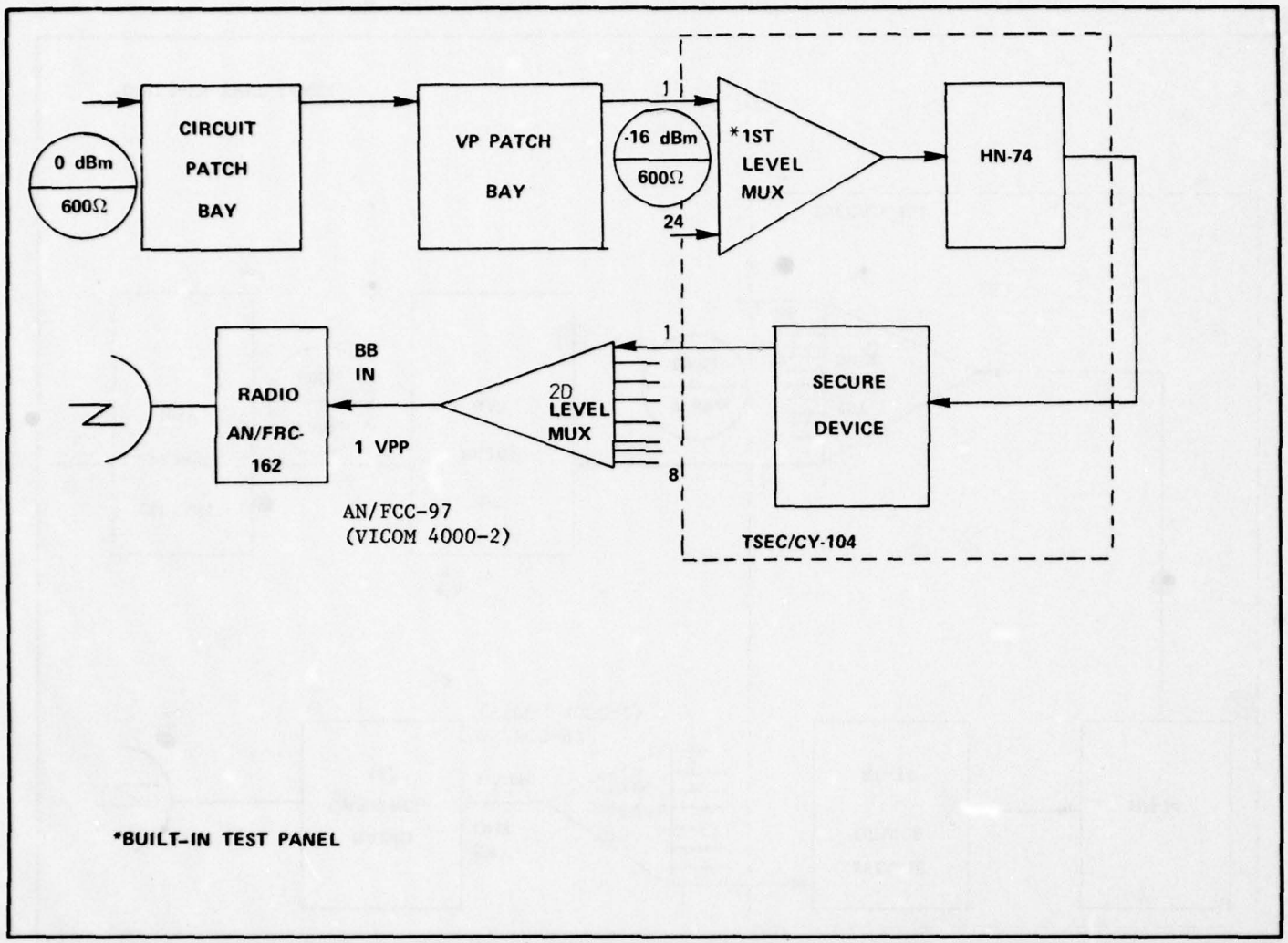


Figure 1-7. Typical AN/FRC-162 and AN/FCC-97 system (transmit).

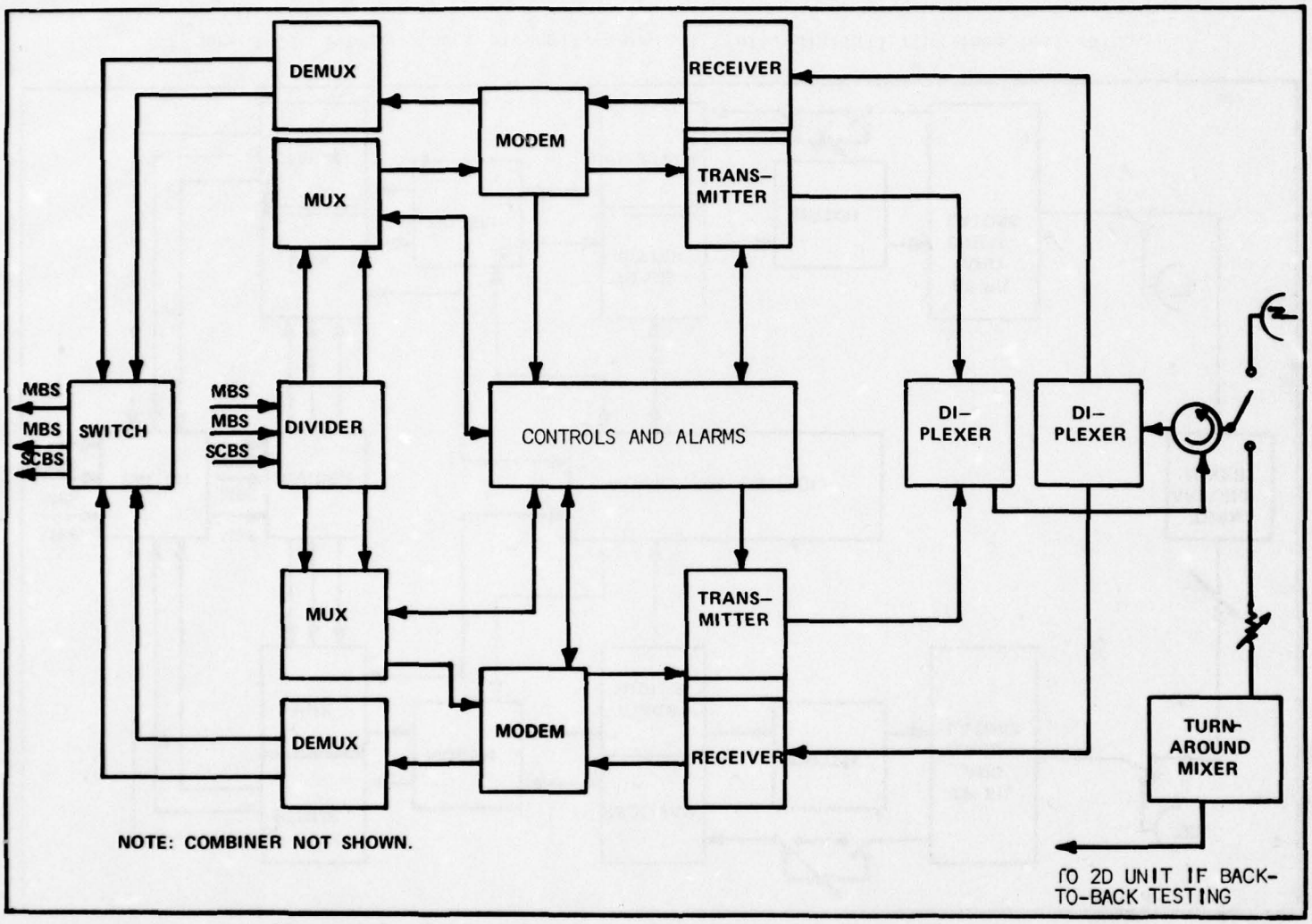


Figure 1-8. Typical frequency diversity system (fully digital).

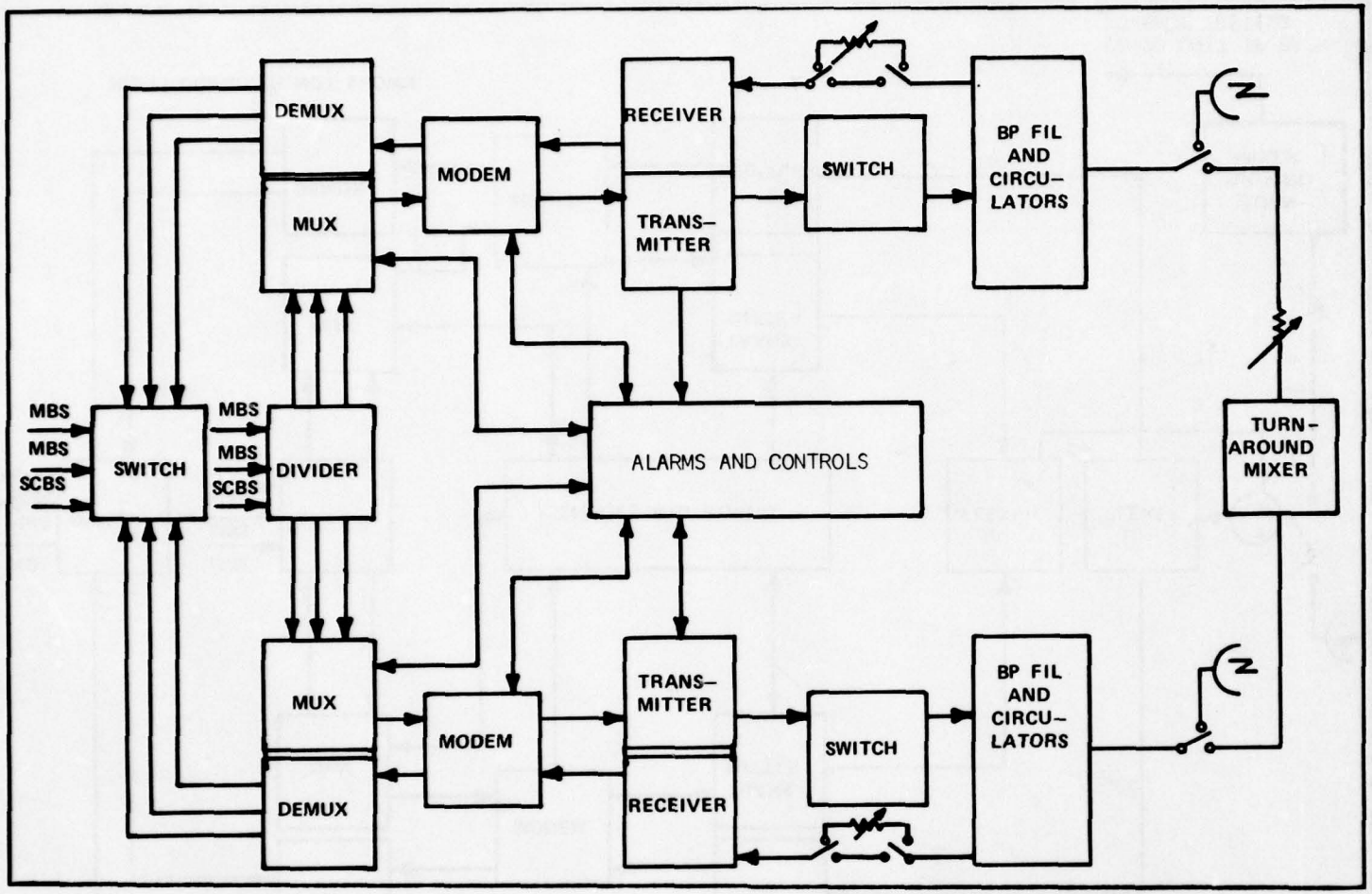


Figure 1-9. Typical space diversity terminal (fully digital) link-loop test setup.

CHAPTER 2

DIGITAL RADIO QUALITY ASSURANCE TEST TEAM MEMBER FUNCTIONS AND RESPONSIBILITIES

2-1. GENERAL.

a. This chapter outlines USACC quality assurance test team responsibilities and duties to implement the requirements of CCR 702-1-3. Test and acceptance test teams will function in accordance with CCR 702-1-2 as implemented by the formal test plan. Testing and responsibilities of onsite personnel will be in accordance with procedures established by DCA and the local command.

b. The test teams will be deployed based on a master test schedule, and the period of deployment will vary dependent on the complexity of the system, transportation problems, and the amount of effort required to optimize the equipment and system. A digital radio evaluation should not exceed 20 days in duration, with an objective of 15 days. This time will also be influenced by the effectiveness of local maintenance programs, proficiency of test team members, and availability of required test equipment and associated hardware.

c. When the test teams are not on temporary duty (TDY), they will analyze raw test data, review test procedures, develop procedures for new systems, prepare revisions to existing test procedures, and prepare operation and maintenance (O&M) procedures to improve onsite techniques. The systems located in close proximity to the test team's home station will be scheduled for a cyclic evaluation when the team is not on TDY to other geographical areas.

d. Although this pamphlet is technical in nature, the test team may examine other nontechnical areas such as facility manning, adequacy of logistical support, environmental conditions, safety practices, and operational procedures. This is based on the fact that problems encountered by the test team in the technical area may be directly attributed to deficiencies in nontechnical areas.

e. Checklists and guidelines for conducting a performance evaluation of digital radio systems will be published in another pamphlet. These checklists will provide for a comprehensive evaluation of all facets of station operation. They will be objective rather than subjective insofar as possible. The checklists will be developed in such a manner that O&M commanders can use the same information in evaluating the performance of onsite personnel, maintenance, and procedures.

2-2. TEST TEAM COMPOSITION.

a. Selection of numbers and types of personnel to be included in the test team will depend upon mission requirements. Additional specialties such as power, environmental control, electromagnetic, or other engineering types may be included in the test team to resolve certain related problems.

b. Personnel selected to man the team must be digital radio trained as well as proficient in systems evaluation techniques. They should also have long-term retainability to reduce training cost and to ensure that the evaluations are conducted in a minimum of time without sacrificing the quality of service being provided.

2-3. TEST TEAM RESPONSIBILITIES.

a. Team Chief. The team chief will:

(1) Supervise test team activities, ensure that all data is collected and analyzed daily, and ensure that required reports are prepared as outlined in appendix B.

(2) Implement deviations to test procedures as may be required and/or approved to ensure that collected data is complete and valid.

(3) Assist the test technicians in setting up test configurations and monitoring and collecting test data.

(4) Coordinate test activities with the command point of contact, other test teams, and personnel as required.

(5) Ensure that all test equipment is accounted for, properly maintained, and protected from loss.

(6) Coordinate system downtime as may be required.

(7) Direct system adjustments to improve the performance and validity of the test data being collected.

(8) Ensure that the completed data package and summary of test results are forwarded to detachment headquarters 5 working days after test completion.

(9) Provide an entrance briefing to site personnel, the local O&M commander, and the senior communications-electronics (C-E) commander or designated representative on the scope and nature of the evaluation and the objectives of the program. At the conclusion of the evaluation, the team chief will give an exit briefing to site and staff personnel, the local O&M commander, and the senior C-E commander. The local DCA representative will be invited to the exit briefing when DCS's are evaluated. As a minimum, the exit briefing will include:

(a) A summary of test results in nontechnical terms to the maximum extent possible.

(b) Significant deficiencies noted during the evaluation that were corrected by the site and/or maintenance personnel with assistance provided by the test team as necessary.

(c) Significant deficiencies remaining and appropriate preliminary technical recommendations for improving the communications systems performance and/or management efficiency. A written list of deficiencies with recommended corrective actions will be provided at the time of the exit briefing. The team chief will advise the O&M commander that noted deficiencies are tentative and subject to change during the final analysis performed by the parent activity.

(d) A list of minor deficiencies that can be corrected by onsite personnel. This list will be provided to the site/unit commander.

(10) Direct sufficient diagnostic testing to isolate a problem or a potential problem and provide positive recommendations to correct any noted anomalies.

(11) Provide the in-country coordinator a telephonic report on a daily basis as to the status of testing, problems encountered, or other areas that may be of interest to detachment headquarters.

(12) Advise the in-country coordinator, on a daily basis, of test, measurement, and diagnostic equipment (TMDE) that has become nonoperational.

(13) Perform a detailed inventory of all equipment in conjunction with the replacement team chief or in-country coordinator.

(14) Advise detachment headquarters of any problems encountered which would influence the test results or cause an alteration of the test schedule.

(15) Ensure that the final test data is representative of system capability.

(16) Maintain a journal throughout the test period that reflects all significant items occurring during the evaluation. As a minimum, the journal will include:

(a) Start and stop times for all test sequences.

(b) Acquisition of systems or circuits for testing and release of the user or time of notification to the technical controller or site personnel that the test sequence has been completed.

(c) Arrival and departure time of test personnel at the facility to be evaluated.

(d) Difficulties encountered in technical, logistical, or administrative areas that impact on the program.

(e) A record of total hours worked by each team member on a daily basis.

(17) Assume responsibility for the health, welfare, morale, and conduct of test team members when in a test status.

(18) Assure adherence of all test team members to locally published dress standards within the command being evaluated.

(19) Review and submit test team travel vouchers as a single package to the detachment commander within 3 working days after returning to detachment headquarters.

b. Team NCOIC. The team NCOIC will:

(1) Assist the team chief in accomplishing the mission to characterize the performance of the digital radio system.

(2) Provide guidance and training to test team members and site personnel on an as-required basis.

(3) Provide technical, personal, administrative, and operational observations to the team chief.

(4) Ensure that the TMDE is calibrated, operational, and securely packed before shipment to the field.

(5) Perform the duties of the team chief during his/her absence.

(6) Perform other duties as assigned.

c. Senior Microwave Repairman. The senior microwave repairman will:

(1) Perform tests and measurements in accordance with the procedures and requirements contained in this pamphlet.

(2) Complete the required data elements for all test data collected ensuring that the data is valid, legible, and representative of system performance.

(3) Initiate corrective adjustment and/or alinement of microwave radio and multiplex equipment within the capabilities of the test team.

(4) Ensure that the TMDE is functioning properly when data is being collected.

(5) Ensure that the interconnecting microwave system is not degrading the digital radio communications service.

(6) Perform organizational maintenance on all assigned vehicles and TMDE.

(7) Perform other duties as assigned.

d. In-Country Coordinator. The in-country coordinator will:

(1) Provide a centralized point of contact for all test activities within the geographical area being evaluated.

(2) Remain cognizant of daily testing activities and maintain a journal of these activities. A copy of the journal will be turned into the detachment for review, and action as required, on a monthly basis or at the conclusion of the test effort.

(3) Initiate requests for authorized outage as may be required and initiate followup action as necessary in monitoring the progress of the request. The request will be provided the O&M command in writing approximately 30 days in advance of the requested outage.

(4) Coordinate with the team chiefs and the O&M to establish a mutually agreeable date and time for briefing the O&M command on the condition of each link evaluated. Notification of the date and time for the briefing will be in writing and will also be provided to the appropriate in-country DCA representative.

(5) Receive defective or nonoperational test equipment from the test teams and replace the equipment from the operational readiness float (ORF) insofar as possible.

(6) Ensure that nonoperational test equipment is turned into the appropriate maintenance activity on an expedited basis. In-country repair facilities will be used to the maximum extent possible; however, equipment may be evacuated to the detachment when deemed appropriate. Equipment evacuated to the detachment must be adequately packed for protection in transit and insured where applicable. The US Mail Service will be used for evacuating defective equipment to the detachment whenever possible.

(7) Maintain adequate records to reflect the status of all detachment test equipment located in the geographical area being evaluated.

(8) Arrange for movement of test equipment between test teams when necessary to ensure that the required onsite tests are completed.

(9) Plan in-country transportation requirements for personnel and equipment and ensure that the O&M commands are provided the requirements in writing far enough in advance to preclude changes to the test schedule. An objective of not less than 10 days prior notice is established for this purpose.

(10) Control, issue, ship, account for, and turn in ORF equipment.

(11) Perform periodic inventories of all detachment assets located in the area being evaluated.

(12) Inventory, secure, and maintain operational control over all vans and equipment not on hand receipt to a team chief. On completing the inventory, the receiving party will receipt for and be responsible for the equipment.

(13) Arrange for billeting, messing, and transportation for test personnel before their arrival in-country. To accomplish this, it may be necessary for the coordinator to visit the sites to be evaluated. Results of the visit or coordination on the availability of transportation, quarters, messing, and

related information will be provided the detachment headquarters by electrical transmission after coordinating with the O&M command.

(14) Provide arriving test personnel with an entrance briefing on local customs, regulations, policies, and restrictions that may influence their activities.

(15) Perform other duties as assigned.

If TDY is performed by the in-country coordinator in conjunction with the Quality Assurance and Testing Detachment (QATD) mission, a travel voucher will be filed with the local finance within 3 working days of completion of TDY and a copy of the completed voucher will be submitted to the detachment commander, ATTN: funds control officer.

2-4. ADMINISTRATIVE REQUIREMENTS.

a. All personnel are required to comply with the uniform standards outlined in DA regulations as may be supplemented by local command policies and directives within the geographical test area. The appropriate uniform will be worn during normal duty hours unless civilian clothing is prescribed or encouraged for wear by the host command.

b. All TDY orders will be prepared and processed by the appropriate headquarters in sufficient time to permit orderly planning by affected personnel. The orders will normally require that personnel use, to the maximum extent possible, government quarters, messing facilities, and transportation to include Military Airlift Command facilities. When it is impractical to use these facilities or their use would directly affect the test team's mission, the orders will be appropriately annotated. When quarters and rations are available in a particular area and the team chief determines that the use of such facilities would adversely affect the mission, the team chief will prepare and submit a written certification so that an appropriate amendment to the original orders can be initiated.

c. An inventory of all blank forms and data sheets will be performed at the conclusion of the evaluation, and replenishments will be requisitioned as required to ensure that the basic load of these items is maintained with the test set.

d. The team chief will ensure that the detachment headquarters is provided a telephone number at which all team members can be reached during normal and off-duty hours. The local O&M command's primary point of contact will also be provided this information.

e. USACC subordinate commands will provide telephone and message service for the detachment in-country coordinator and the test team as may be required during the evaluation.

2-5. LOGISTICAL SUPPORT.

a. USACC subordinate commanders will be responsible for logistical support of the test team while the test team is deployed within their geographical area. This support includes but is not limited to:

(1) Transporting of personnel and equipment to and from the test site.

(2) Arranging for billeting and messing facilities. Consideration must be given to the fact that the test teams are expected to work during nonduty hours, holidays, and weekends in accomplishing the test objectives. Test personnel are also expected to reduce and analyze the test data when testing is not being accomplished.

(3) Arranging for TMDE repair and calibration within the capabilities of the area maintenance supply facility (AMSF) and for A-level calibration and repair as may be required by the test teams.

(4) Providing security for the test instrumentation during periods that the test teams are not onsite.

(5) Augmenting the TMDE organic to the test team as required and within local capabilities.

(6) Providing qualified maintenance technicians to assist the test team throughout the evaluation. These individuals may be site personnel or technicians from the local AMSF; however, they should be made available on a full-time basis for maximum exposure to the test procedures, cross training, and effectiveness of required corrective actions.

b. When the detachment headquarters is scheduled to perform an evaluation on digital radio systems operated and maintained by other military departments or services, coordination with the appropriate level of command will be effected to ensure that the required support is available.

CHAPTER 3

ANTENNA ALINEMENT (DT-200)

3-1. GENERAL.

a. The purpose of this test is to properly aline the antenna beam(s) both in azimuth and in elevation.

b. If the antennas are not properly alined, the radio-path-link performance measurements will be inaccurate and could be meaningless and misleading. By definition, the proper antenna beam alinement is construed to mean that position of the antenna beam(s), along the radio path, which yields the maximum value of the long-term median received signal level (RSL). The long-term median RSL is obtained from the cumulative distribution of the short-term median RSL. The short-term period is defined as the run period, which is determined by the time-varying characteristics of the RSL, and can vary from a few minutes to an hour or more. The short-term median RSL can be obtained from a stripchart recording.

c. Two methods of alining the antenna beam(s) in azimuth and in elevation are outlined below:

(1) The first method is the fast scan technique which is used when it is possible to swing the antenna beam rapidly by vertical or horizontal movement of the entire antenna feedhorn or by physical movement of the entire antenna structure. In order to employ this technique, the antenna beam must be moved at such a rate as to produce a paper stripchart recording or an indicating meter reading of the RSL which is distinct from the recording obtained when the antenna remains fixed for a similar time period. In other words, the recorded RSL must show a definite peak as the antenna beam is swung through its optimum position. For maximum efficiency, the fast scan technique should be employed simultaneously at both ends of a radio link and coordinated by means of two-way voice communication over the maintenance coordination channel between the test operators at both ends.

(2) The second method consists of measuring the true change in the run-median RSL associated with particular positions of the antenna beam. In this case, the run is defined as a period of time which is sufficient for the time-varying RSL to establish a median value. Dependent upon the type of RF signal, the run period could vary from a few minutes to an hour or more. Since we are dealing with a time-varying RSL, with (possibly) a different median value for each run, it is necessary to make simultaneous median RSL measurements over a parallel radio path with fixed antennas at each end. These run-median RSL's are used as reference values to correct the corresponding measured run-median RSL's on the path with the variable antenna beam position. This correction is necessary due to the time-varying path effect on the median RSL from one run to the next.

d. The first method described is much faster and more accurate; however, it requires that the antenna be swung rapidly and hence, in general, does not

apply to antennas greater than 30 feet in diameter. Furthermore, line-of-sight (LOS) radio links using small and easily maneuverable antennas can be alined by manually adjusting the antenna orientation while simultaneously monitoring and maximizing the RSL. Therefore, the smaller antennas for LOS links should be alined by the first method.

e. The requirement to perform the antenna alinement test is usually indicated by the degree of similarity between the measured median RSL's of the various receivers over the same radio link. The need to perform this test would also be indicated if the measured long-term median RSL's differ considerably (3 to 5 dB) from the calculated long-term median as contained in the standard engineering plan, even though the individual receiver short-term and long-term median RSL's are similar.

3-2. SPECIFICATIONS. The radio shall operate as specified in the standard engineering plan, test and acceptance report, or calculated values as appropriate.

3-3. TEST EQUIPMENT REQUIRED.

a. Stripchart recorder.

b. Root mean square (RMS) voltmeter.

c. Power meter with bolometer/thermistor.

d. RF sweep generator.

e. 70-megahertz (MHz) logarithmic/linear amplifier.

f. 20-Hz low-pass filter.

g. Direct current (DC) polarity reversal amplifier.

h. Variable time constant.

i. Electronic voltmeter.

3-4. TEST PROCEDURES.

a. To determine if an antenna alinement is required, the individual RSL's of all the receivers operating on the same link will be recorded for a minimum of 24 hours.

NOTE: Antenna alinement should only be performed by trained antenna technicians due to the hazards involved.

b. If the automatic gain control (AGC) voltages of the radio receivers are to be used and have not been previously calibrated, this should be performed as outlined in DT-224.

c. To record the RSL, proceed as follows:

(1) Connect the equipment as shown in figure 3-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Set the frequency of the RF sweep generator to the center frequency of the radio receiver. The calibration of the RF sweep generator will be in terms of the RF power level at the output of the cable connector; that is, the RF signal power into the bolometer/thermistor (as read on the RF power meter) versus the dial reading of the RF sweep generator output attenuator.

NOTE: The 10-dB attenuator is inserted at the output of the RF sweep generator to reduce impedance mismatch effects. The attenuator may not be necessary if the output impedance of the generator matches the impedance of the cable and the input impedance of the radio receiver.

(3) Calibrate the recorder channel by marking each deflection of the recorder pen with a corresponding RF signal power level at the input terminal of the receiver. When calibrating, select the midscale (center of the chart), end scale (edge of the chart), and sensitivity values that are suitable for the quiescent value and dynamic range of the RSL to be recorded.

(4) If a DC polarity reversal amplifier is not available, bypass the logarithmic amplifier (fig. 3-1) and go directly to the recorder input. The DC voltage at the output of the 0- to 20-Hz low-pass filter may be adequate to eliminate both the DC polarity reversal amplifier and the logarithmic amplifier as shown in figure 3-1.

(5) From the calculated value or standard engineering plan, determine the median RSL. This will be the level at which the output RF sweep generator must be set to center the pen on the chart. Mark this level on the chart recording.

(6) Calibrate the logarithmic amplifier-recorder for a full-scale reading above and below the expected median RSL by changing the output power of the generator. Select a range of full-scale deflections that will ensure all variations are recorded. The recording should be calibrated in 5- or 10-dB steps over the entire range of expected variations. On some links, 50 dB may be required. Further, on stable LOS links, it may only be necessary to use a full-scale spread of no more than 10 dB.

(7) Once the recorder has been calibrated and all pertinent calibration marks appropriately annotated, remove the RF sweep generator and connect the receiver to its normal antenna.

(8) Adjust the stripchart speed to provide a clear indication of any variations without bunching. This is especially important on fast time-varying systems such as transhorizon; otherwise, the period of any deep fades may be obscured.

(9) Divide the stripchart recording obtained from the test period into 10-minute runs. Determine the median of each run using a stretched string held parallel to the time axis and located at the visually estimated median level. Record the run-median for each RSL (if more than one receiver is used) on figure 3-2 (DCA Form (Test) T1-8), using dBm scale units to fit the measured RSL data. Determine the long-term median for each RSL by adding the total number of strokes and dividing this number by 2. Starting at the top level of the chart, count each stroke mark until the mark is reached which corresponds to the number obtained in the above division. The dBm level containing this mark is the long-term median for the particular RSL being measured. A comparison between the long-term median RSL's of the individual receivers operating on the link and the calculated value will indicate the need for an antenna alinement. Also the average of all measured long-term medians will be compared to the calculated value, and if found to be appreciably different, antenna alinement may be indicated.

d. When it has been determined from the recorded RSL that an antenna alinement is necessary, either of the methods described in paragraph 3-1c may be used following the steps in subsequent paragraphs.

e. To record RSL, using the fast scan technique, proceed as follows:

(1) From the above test data, select the receiver having the lowest RSL at both ends of the radio link. Connect the output (AGC or intermediate frequency (IF)) of this receiver as shown in figure 3-1. In order to obtain a well-defined peaking or maximizing signal on the chart recorder, which corresponds to an optimum antenna beam position, it may be necessary to use several trial combinations of antenna beam scan rates, paper chart speeds, and recording time constants. The time constant should be adjusted to remove the rapid and large RSL variations in excess of approximately one fade per second.

(2) At one end of the link, swing the appropriate antenna beam in azimuth to obtain a peaking indication on the recording or meter indicator and RSL which will indicate the optimum antenna/beam position in azimuth. Record the following on figure 3-3 (DD Form 2105): the peak RSL, time of occurrence of the peak RSL, and the position of the antenna/beam for peak RSL. On the stripchart recording, note the time of occurrence of the peak RSL and the antenna/beam position. Repeat this procedure for at least 10 times, with a time interval of approximately 1 minute between the antenna/beam swings.

(3) If the data was taken with a meter and recorded on figure 3-3 (DD Form 2105), plot the variation of the optimum azimuth positions of the antenna beam versus time on figure 3-4 (DD Form 2094). From this curve, determine the median of the optimum antenna position for the test time period and lock the antenna in this azimuth position. The same would hold true for the positioning if using a stripchart to record the variations as shown in figure 3-5.

(4) Using the steps outlined in paragraphs 3-4c (1) through (3), as applied to the elevation, determine and lock the antenna in the optimum elevation position.

(5) Using the steps outlined in paragraphs 3-4c (1) through (4), optimize the position in azimuth and elevation of the corresponding antenna on the other end of the link. The procedure may have to be repeated several times before the antennas are optimized for maximum RSL.

(6) Repeat the above steps for the remaining antennas at both ends of the link, if required.

NOTE: On LOS systems, it may be necessary to attenuate the incoming RF signal to the receiver for precise alinement. This is especially applicable to those links where the RSL saturates the receiver and the AGC does not respond to minor changes in the RSL.

f. To record RSL, using the run-median antenna alinement technique, proceed as follows:

(1) From the RSL recording, select the lowest long-term median RSL and a reference RSL which is the RF signal transmitted from and received by the fixed antenna not under test. Record these two RSL's on the stripchart recording. Calibrate both recorder channels in dBm units, using the procedure described in paragraph 3-4c.

(2) Adjust the recorder chart speed and time constant, and start run 1. The run periods should be at least 5 minutes in length. For each run, record the start and stop times on the stripchart and record the data on figure 3-6 (DD Form 2106). Determine and record the median RSL's of the reference and the adjusted antennas/beams on the data sheet for the method of determining the run-median RSL's. Adjust the antenna to a new azimuth position and continue as above for succeeding new antenna positions and runs. Note that two consecutive runs are required to obtain a corrected value associated with the change in the measured median reference signal RSL between consecutive runs which is used to obtain a corresponding corrected value for the change in the measured median of the adjusted-signal RSL.

(3) Repeat paragraph 3-4e(1), covering a sufficient range of azimuth positions to show a definite optimum azimuth position for the antenna.

(4) Repeat paragraphs 3-4e (1) through (3) for the antenna elevation positions.

(5) Plot the data from the right-hand column of figure 3-6 (DD Form 2106) on figure 3-4 (DD Form 2094) in terms of: adjusted antenna position (both azimuth and elevation) versus corrected change in adjusted antenna RSL. Sufficient data should be obtained to plot the curves as shown in figure 3-5 in order to determine the optimum azimuth and elevation positions for the adjusted antenna. Set and lock the antenna to the optimum azimuth and elevation positions.

(6) The above procedures apply to the remaining antennas on the link, if required.

3-5. DATA RECORDING AND ANALYSIS.

a. Record all data on applicable data sheets and summarize the test results on figure 3-7 (DD Form 2091).

b. Restore the system to normal operations.

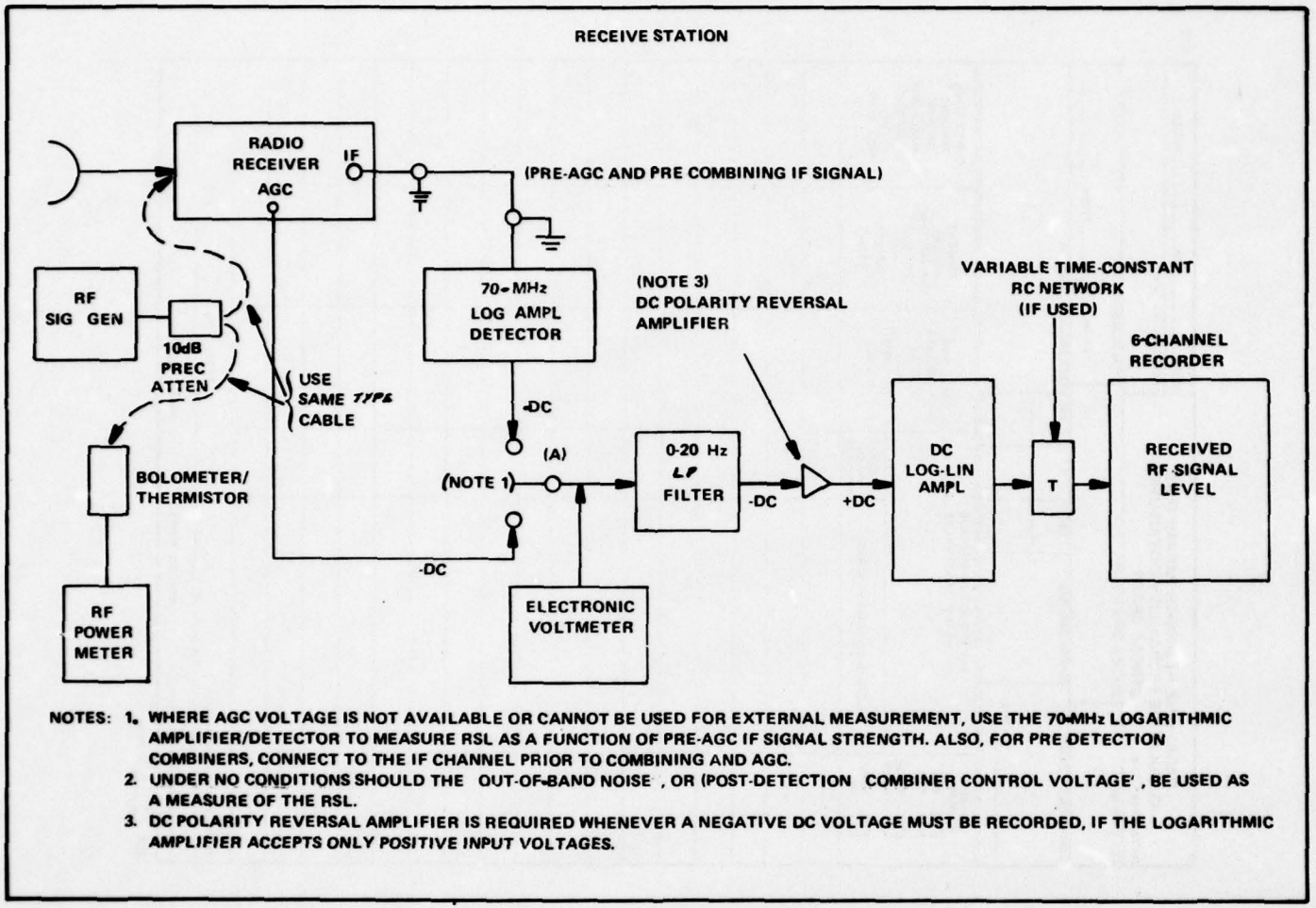


Figure 3-1. RSL recording test setup.

CCP 702-11

RADIO LINK RECORDED PARAMETERS
CUMULATIVE PROBABILITY DISTRIBUTION
STROKE CHART

DATA SHEET T1-8

PAGE _____ OF _____ PAGES

DATE *(day, mo., year)*

DCS LINK NO.	STATION UNDER TEST	RUN NUMBERS FROM: _____ THRU: _____

DURATION OF RUNS _____ MIN.	RADIO REC. NO.	SG	G	V. CH.	TEST ENGR. SIGNATURE

RUN MEDIAN: ☐ RSL, dBm ☐ NOISE, dBm0 ☐ ST/N, dB	NUMBER OF RUN MEDIANS AT THE INDICATED VALUE: INDIVIDUAL -RUN STROKES	TOTAL NO. OF STROKES	TOTAL TIME RUN MEDIANS WERE AT THE INDICATED VALUE	PERCENT OF TIME RUN MEDIANS WERE AT THE INDICATED VALUE	CUMULATIVE PERCENT OF TIME RUN MEDIANS *exceeded* THE INDICATED VALUE

TOTAL NUMBER OF RUNS = TOTAL TIME = MIN.

LONG-TERM MEDIAN: RSL = dBm; OR, NOISE = dBm0; OR S_T/N = dB

DCA FORM (TEST) T1-8
MAR 73

Figure 3-2. Radio link recorded parameters cumulative probability distribution stroke chart data sheet.

ANTENNA ALIGNMENT (FAST SCAN METHOD)

PAGE _____ OF _____ PAGES

DATE

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

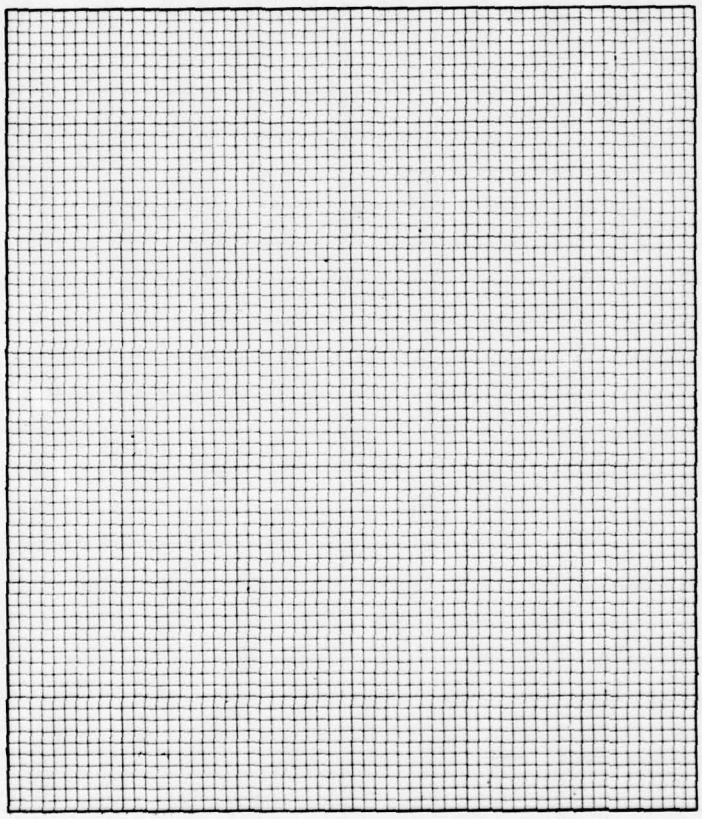
RADIO RCVR NO.	RF SIGNAL POLARIZATION ☐ VERT. ☐ HORIZ.	RADIO PATH NO.	RADIO TRANS NO.	REC'D RADIO FREQUENCIES

RUN NO.	TIME			DUR., SEC.	RECORDER CHART SPEED MM/SEC.	RECORDER TIME CONSTANT SEC.	ANTENNA/BEAM POSITION	
	START Z	RSL PEAK Z	STOP Z				AZIMUTH	ELEVATION

DD FORM 1 SEP 77 2105

Figure 3-3. Antenna alinement (fast scan method) data sheet.

GENERAL PURPOSE GRAPH PAPER DATA SHEET			PAGE _____ OF _____ PAGES DATE (day, mo, year)
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE
TITLE OF PERFORMANCE PLOTTED			TEST NO.



☐ RELATIVE ENVELOPE DELAY (μsec) ☐ AMPLITUDE (dBm)

DD FORM 2094

Figure 3-4. General purpose graph data sheet.

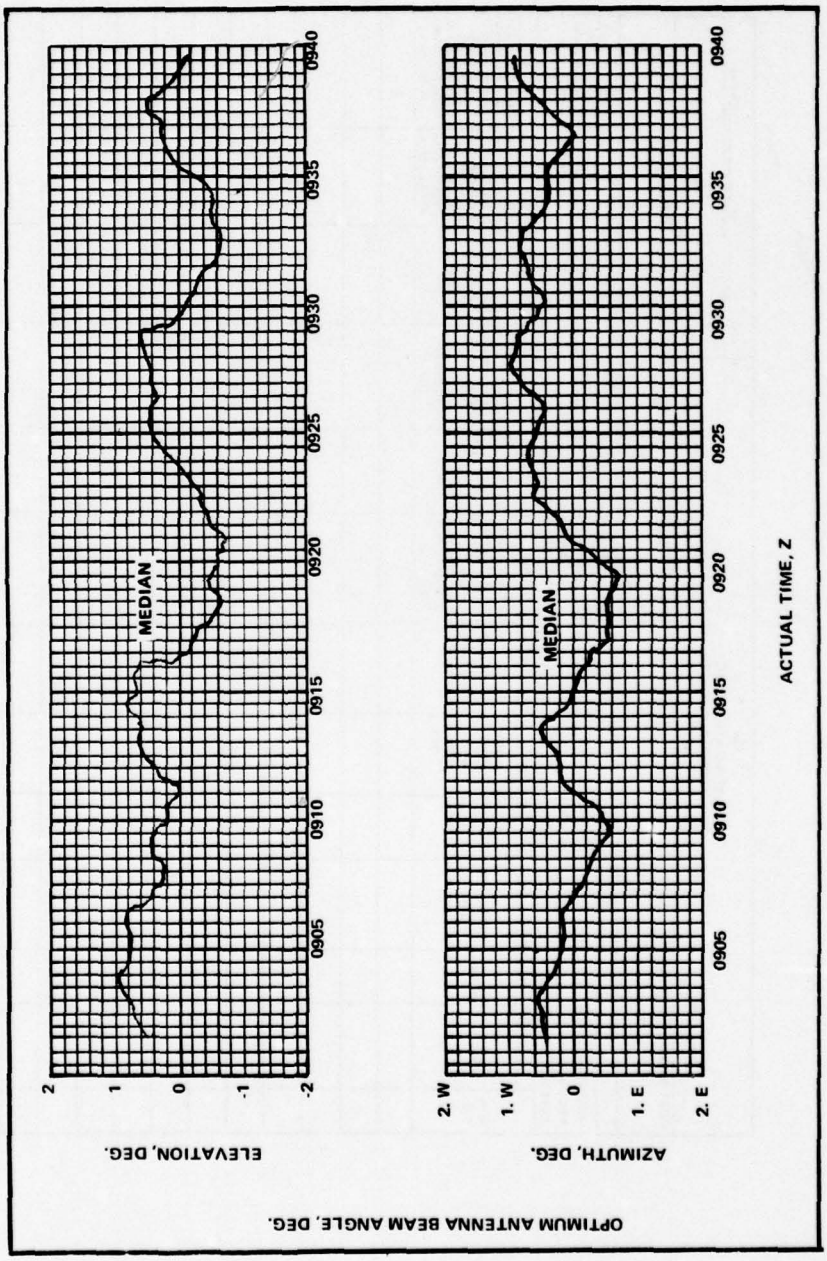


Figure 3-5. Typical plot of RSL.

ANTENNA ALIGNMENT
(RUN MEDIAN METHOD)

PAGE _____ of _____ PAGES
DATE

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

REFERENCE RSL

ANTENNA POS: AZ. _____ EL. _____
RECEIVER NO: _____
ANTENNA NO: _____

RECORDER CH. NO.: _____
RADIO PATH: _____
RF SIG. POL. ☐ VERT. ☐ HOR.

ADJUSTED ANTENNA/BEAM RSL

RECEIVER NO.: _____
ANTENNA NO.: _____
RECORDER CH. NO.: _____

RADIO PATH: _____
RF SIG. POL. ☐ VERT. ☐ HOR.

RUN NO.	RUN TIME PERIOD			RECORDER		REFERENCE RSL		ADJUSTED–ANTENNA/BEAM				
								ANTENNA POSITION		RECEIVED RF SIGNAL, RSL		
	START	STOP	DURATION MIN.	CHART SPEED	TIME CONSTANT SEC. (T=RC)	MEASURED MEDIAN RSL dBm	CORRECTION FOR CHANGE IN RSL BETWEEN CONSECUTIVE RUNS, dB	AZIMUTH DEG.	ELEVATION RELATIVE TO HORIZONTAL DEG	MEASURED MEDIAN RSL dBm	MEASURED CHANGE IN MEDIAN RSL BETWEEN CONSECUTIVE RUNS: dB	CORRECTED CHANGE IN MEDIAN RSL BETWEEN CONSECUTIVE RUNS, dB

DD FORM 1 SEP 77 2106

Figure 3-6. Antenna alinement (run-median method) data sheet.

TEST COVER PAGE	☐ Preliminary ☐ Final	PAGE_____ OF _____ PAGES DATE
TEST NO. T_____	TEST TITLE	
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION
THROUGH STATIONS		
COMMENTS:		
STANDARDS/SPECIFICATIONS:		
TEAM CHIEF CERTIFICATION		
TYPED NAME, RANK/GRADE and TITLE	SIGNATURE	

DD FORM 1 SEP 77 2091

Figure 3-7. Test cover page.

CHAPTER 4

TIME DOMAIN REFLECTOMETRY (TDR) OF ANTENNA TRANSMISSION LINES (DT-201)

4-1. GENERAL.

a. The purpose of this test is to obtain the return loss versus distance profile of the antenna transmission lines from which the magnitude and location of discontinuities (faults such as breaks, corrosion, misalinement, foreign objects, etc.) can be easily determined and corrective action taken.

b. Since the antenna end of the transmission line is relatively inaccessible, it is desirable and at times necessary to determine the electrical condition of these lines from a convenient single port measurement of the reflected energy by means of the TDR technique.

c. The TDR technique can be compared to a closed loop radar system in which an RF pulse burst is transmitted down the transmission line, and the energy reflected back from any discontinuity or impedance variation is detected and displayed. The distance to a discontinuity determines the time that it takes for the reflected energy to return to the (reference) detector, and the magnitude of the reflected signal is a function of the return loss (reflection coefficient) at the point of the discontinuity (reflection).

d. This test is primarily a diagnostic aid by which to locate a fault or discontinuity during system troubleshooting. One of the major limitations of this test is the single frequency used for the tone burst which is generally not suitable for waveguide and antenna systems used in FM systems. This problem can be overcome by performing a number of measurements at discrete frequencies over the spectrum of interest. A more suitable test for FM systems would be the ranging test described in a subsequent chapter.

e. This test may be used by the installer or quality assurance personnel to isolate a particular problem in the waveguide or antenna transmission line system as directed.

4-2. SPECIFICATIONS.

a. The following criteria applies to the TDR of antenna transmission lines. (MIL-STD-188-313)

(1) The input to the RF transmitter shall exhibit a return loss of 26 dB over the measurement bandwidth, centered on 70 MHz.

(2) The return loss, as measured toward the RF interface point, with all RF transmitting equipment installed and the RF interface point terminated in its characteristic impedance, shall not be less than 26 dB over the measurement bandwidth, centered on the assigned frequency.

(3) The return loss toward the antenna within a discrete frequency block (350 to 8400 MHz) shall not be less than 26 dB.

(4) The return loss toward the antenna within a discrete frequency block (1700 to 15,000 MHz) shall not be less than 28 dB.

(5) The return loss when measured at the RF interface point toward the receiver shall not be less than 32 dB over the measurement bandwidth, centered on the assigned frequency.

NOTE: The specifications stated in subparagraph a above do not directly apply to this test; however, they have been included as information to be used when measuring the level of any discontinuity and as a basis for comparison.

b. The voltage standing wave ratio (VSWR) (AN/FRC-162) looking into the RF interface point from the antenna feedline shall not be more than 1.05:1 (32-dB return loss) over a 15-MHz band, centered on the transmit and receive carrier frequencies. (SCCC-73017)

c. The VSWR (AN/FRC-( )) looking into the RF interface point from the antenna feedline shall not be more than 1.3:1 over a 20-MHz band, centered on the transmit and receive carrier frequencies. The radio shall provide specified performance when the antenna feedline presents a VSWR of 1.5:1 at any phase angle. (CCC-74049)

NOTE: Although the terminology in subparagraphs b and c above (VSWR) is referred to as return loss in the document cited, the criteria applies.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

4-3. TEST EQUIPMENT REQUIRED.

a. TDR fault locator.

b. Coaxial double stub tuner.

c. Coaxial and waveguide adapters, as required.

d. Frequency counter.

4-4. TEST PROCEDURES.

a. Turn off the RF transmitter associated with the transmission line to be tested. Disconnect the transmission line at the transmitter output port or any other point at which the test is to be performed.

b. Connect the test equipment as shown in figure 4-1 and allow approximately 30 minutes for warmup and stabilization.

c. Before connecting the fault locator to the coaxial stub tuner and the transmission line under test, calibrate it as follows:

(1) Tune the fault locator to the test frequency desired by using the frequency counter to arrive at the precise frequency used for the test. If more than one measurement is to be made over the frequency spectrum, the measurements should be made at a number of discrete frequencies within the mission spectrum.

(2) Set the propagation constant control for the type of transmission line and test frequency in accordance with the instructions provided with the fault locator.

d. Connect the fault locator to the coaxial tuner and transmission line under test through the necessary adapter as shown in figure 4-1. The coaxial tuner should be used to eliminate (minimize) the impedance mismatches caused by the adapter to the transmission line under test and to facilitate the display of return loss data at short distances (at less than 10 feet) from the point of measurement.

e. To calibrate the X-Y recorder for the return loss versus distance plot, manually sweep the distance on the fault locator until the end of the transmission line being tested is reached and note the range of return loss values observed. Set the recorder controls for the distance (X-axis) and return loss (Y-axis) to accommodate the above determined ranges and then plot the return loss versus distance profile.

f. If the TDR is equipped for automatic sweep, sweep the mission spectrum for the length of the transmission line under test to obtain the return loss versus distance profile. If the TDR is not equipped for automatic sweep, manually adjust the TDR over the mission spectrum while measuring the frequency with the frequency counter. A sufficient number of frequencies should be used to provide a smooth curve as shown in figure 4-2.

g. Low return loss indicates faults in the transmission line at that distance away from the measurement point. These locations or areas in the transmission line will be examined for bends, breaks, misalinement of flanges, corrosion, or foreign objects.

4-5. DATA RECORDING AND ANALYSIS.

a. Record all data on figure 3-4 (DD Form 2094) and summarize the test results on figure 3-7 (DD Form 2091).

b. Notify the responsible activity of any required ongoing corrective actions.

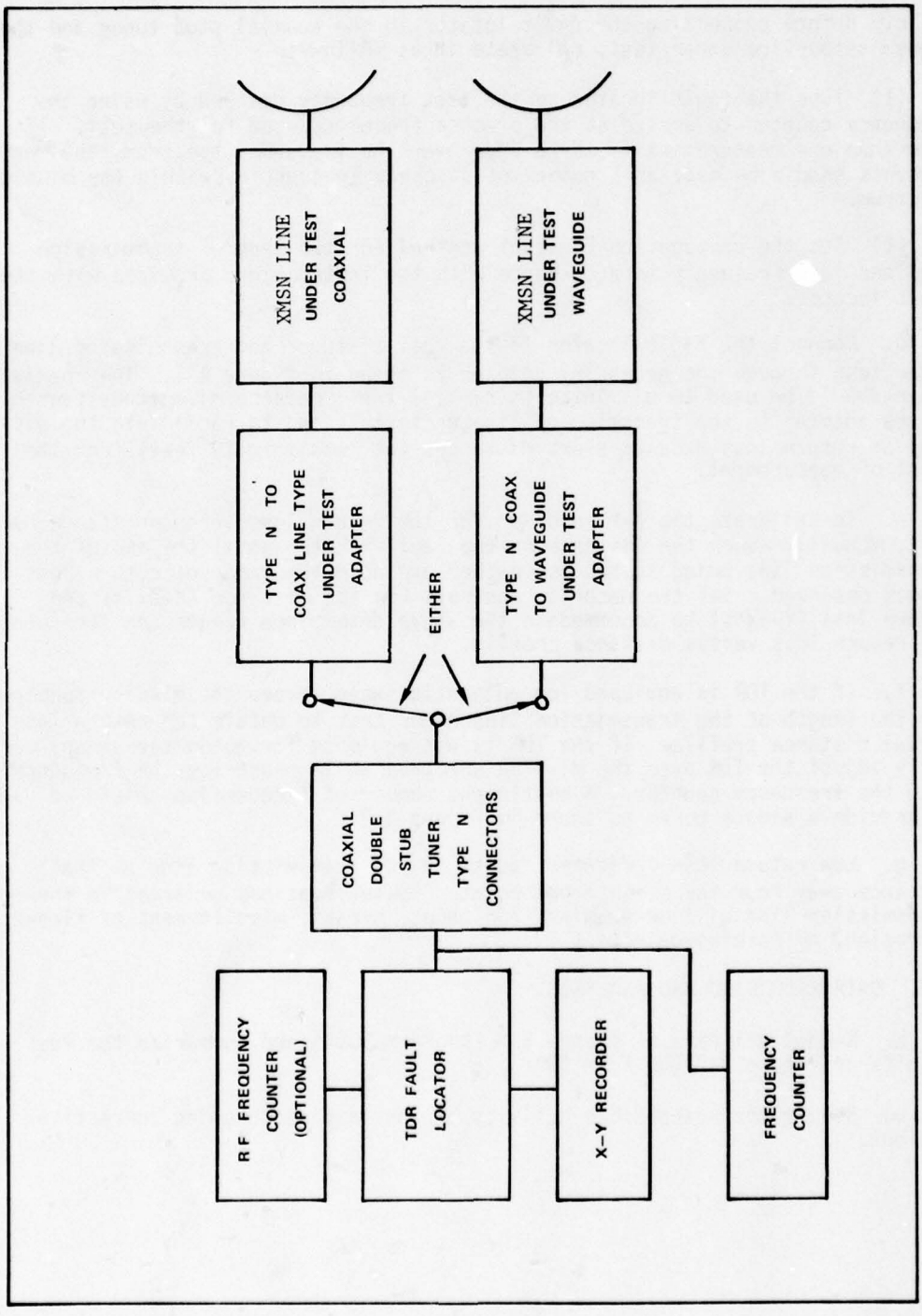


Figure 4-1. Transmission line TDR test setup.

GENERAL PURPOSE GRAPH PAPER

PAGE _____ OF _____ PAGES

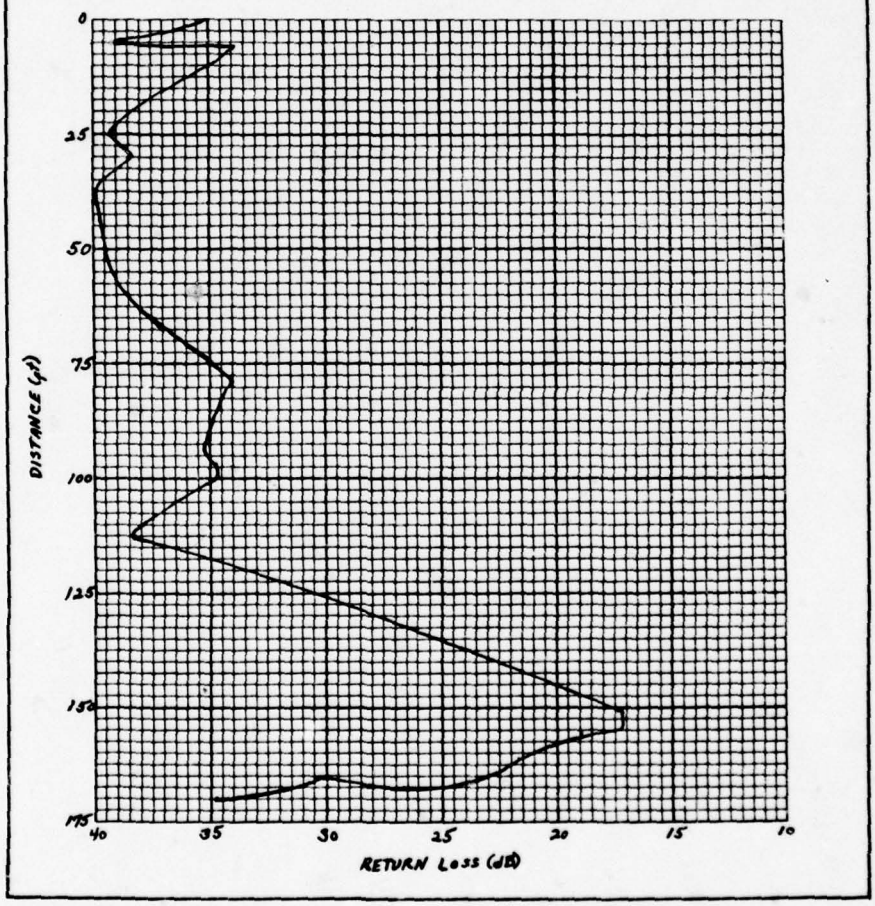
DATE (day, mo., year)

DATA SHEET

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE

TITLE OF PERFORMANCE PLOTTED: TDR of Antenna Transmission Lines

TEST NO.: DT-201



DD FORM 2094

Figure 4-2. Typical return loss vs distance of transmission line.

CHAPTER 5

FREQUENCY DOMAIN REFLECTOMETRY OF ANTENNA TRANSMISSION LINES (DT-202)

5-1. GENERAL.

a. The purpose of this test is to automatically determine the return loss versus frequency characteristics at the input port to the antenna transmission lines from which the degree of impedance mismatch (VSWR) and the amount of reflected power can be determined.

b. The advantage of this test over DT-201 is that the transmission lines can be automatically swept over a band of frequencies above and below the assigned frequency, and the data would be automatically recorded by the X-Y plotter. The method used in DT-201 may also be performed at discrete frequencies above and below the assigned frequency; however, it is more time-consuming than the automatic method.

c. Since the modulation of an FM system causes the carrier to be shifted over a rather wide range of frequencies, it is important to determine the return loss over the entire bandwidth of the FM signal. If a single measurement is made at the assigned frequency, it is possible that reflections (VSWR) may be causing a problem at some point distant from the carrier which would go undetected with a single frequency measurement.

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by the installer or quality assurance personnel during onsite testing as directed.

5-2. SPECIFICATIONS.

a. The following criteria applies to the frequency domain reflectometry of antenna transmission lines. (MIL-STD-188-313)

(1) The input to the RF transmitter shall exhibit a return loss of 26 dB over the measurement bandwidth, centered on 70 MHz.

(2) The return loss, as measured toward the RF interface point, with all RF transmitting equipment installed and the RF interface point terminated in its characteristic impedance, shall not be less than 26 dB over the measurement bandwidth, centered on the assigned frequency.

(3) The return loss toward the antenna within a discrete frequency block (350 to 8400 MHz) shall not be less than 26 dB.

(4) The return loss toward the antenna within a discrete frequency block (1700 to 15,000 MHz) shall not be less than 28 dB.

(5) The return loss when measured at the RF interface point toward the receiver shall not be less than 32 dB over the measurement bandwidth, centered on the assigned frequency.

NOTE: The specifications stated in subparagraph a above do not directly apply to this test; however, they have been included as information to be used when measuring the level of any discontinuity and as a basis for comparison.

b. The VSWR (AN/FRC-162) looking into the RF interface point from the antenna feedline shall not be more than 1.05:1 (32-dB return loss) over a 15-MHz band, centered on the transmit and receive carrier frequencies. (SCCC-73017)

c. The VSWR (AN/FRC-( )) looking into the RF interface point from the antenna feedline shall not be more than 1.3:1 over a 20-MHz band, centered on the transmit and receive carrier frequencies. The radio shall provide specified performance when the antenna feedline presents a VSWR of 1.5:1 at any phase angle. (CCC-74049)

NOTE: Although the terminology in subparagraphs b and c above (VSWR) is referred to as return loss in the document cited, the criteria applies.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

5-3. TEST EQUIPMENT REQUIRED.

a. RF sweep generator.

b. Directional couplers.

c. RF attenuators (50-dB range).

d. RF short.

e. X-Y recorder.

f. Spectrum analyzer with camera.

g. Power meter.

h. Frequency counter.

5-4. TEST PROCEDURES.

a. Turn off the RF transmitter associated with the transmission line to be tested. Disconnect the transmission line at the transmitter output port or any other point at which the test is to be performed.

b. Complete the top portion of figure 3-4 (DD Form 2094).

c. Before connecting the test equipment to the transmission line to be tested, calibrate the X-Y recorder as follows:

(1) Connect the RF attenuator and short combination to the output of the directional coupler as shown in figure 5-1. Allow approximately 30 minutes for warmup and stabilization.

(2) Set the RF sweep generator to sweep across the frequency range desired, and set the controls on the X-Y recorder to display this range on the full X-axis of the data sheet. The sweep speed of the generator must be adjusted to ensure that the tracking capability of the X-Y recorder is not exceeded. Mark the frequency scale on the data sheet by manually sweeping the RF sweep generator across the frequency range and recording the frequencies as observed on the frequency counter.

(3) With the RF attenuator set at 40 dB, adjust the power output controls of the RF sweep generator and the Y-axis controls of the recorder so that the pen is at the bottom line of the graph on the data sheet. Mark this level "40-dB Return Loss" on the Y-axis of the graph. Next, set the attenuator at 10 dB and adjust the sensitivity of the X-Y recorder so that these two levels will fall on the bottom and top of the graph, respectively. This may require several trial settings to get the pens properly positioned. Successively set the attenuator at 30, 25, 15, and 10 dB and mark these levels on the Y-axis of the data sheet. If desired, the Y-axis (return loss) scale can be marked for VSWR or reflection coefficient calibration using the conversion factors given in table 5-1.

d. From this point on, do not change the RF sweep generator output power, the leveling gain control, or any of the controls on the X-Y recorder.

e. Remove the RF attenuator and short combination used for calibration and connect the calibrated test equipment to the transmission line to be tested. On figure 3-4 (DD Form 2094), record the return loss versus frequency characteristics of the input port of the transmission line being tested by using the previously preset automatic sweep mode of the RF sweep generator or manually tuning the generator across the frequency range of interest.

f. If a spectrum analyzer is used, set the RF sweep generator and spectrum analyzer to cover the desired frequency range. The analyzer sweep rate should be set slower than the sweep rate of the generator in order to obtain a smooth curve.

g. With the RF calibration attenuator set to 0 dB, set the 0-dB return loss line on the analyzer display. This line should be level throughout the selected frequency range.

h. Insert attenuation as necessary to calibrate the return loss display. The value of the attenuator corresponds directly to the calibration line displayed.

i. From this point on, do not change any level controls on the RF sweep generator or the spectrum analyzer.

j. Remove the short from the output of the directional coupler, set the RF calibration attenuator to 0 dB, and connect the equipment to the system to be tested. Experiment with various camera settings and analyzer/generator sweep rates to obtain an acceptable quality photograph.

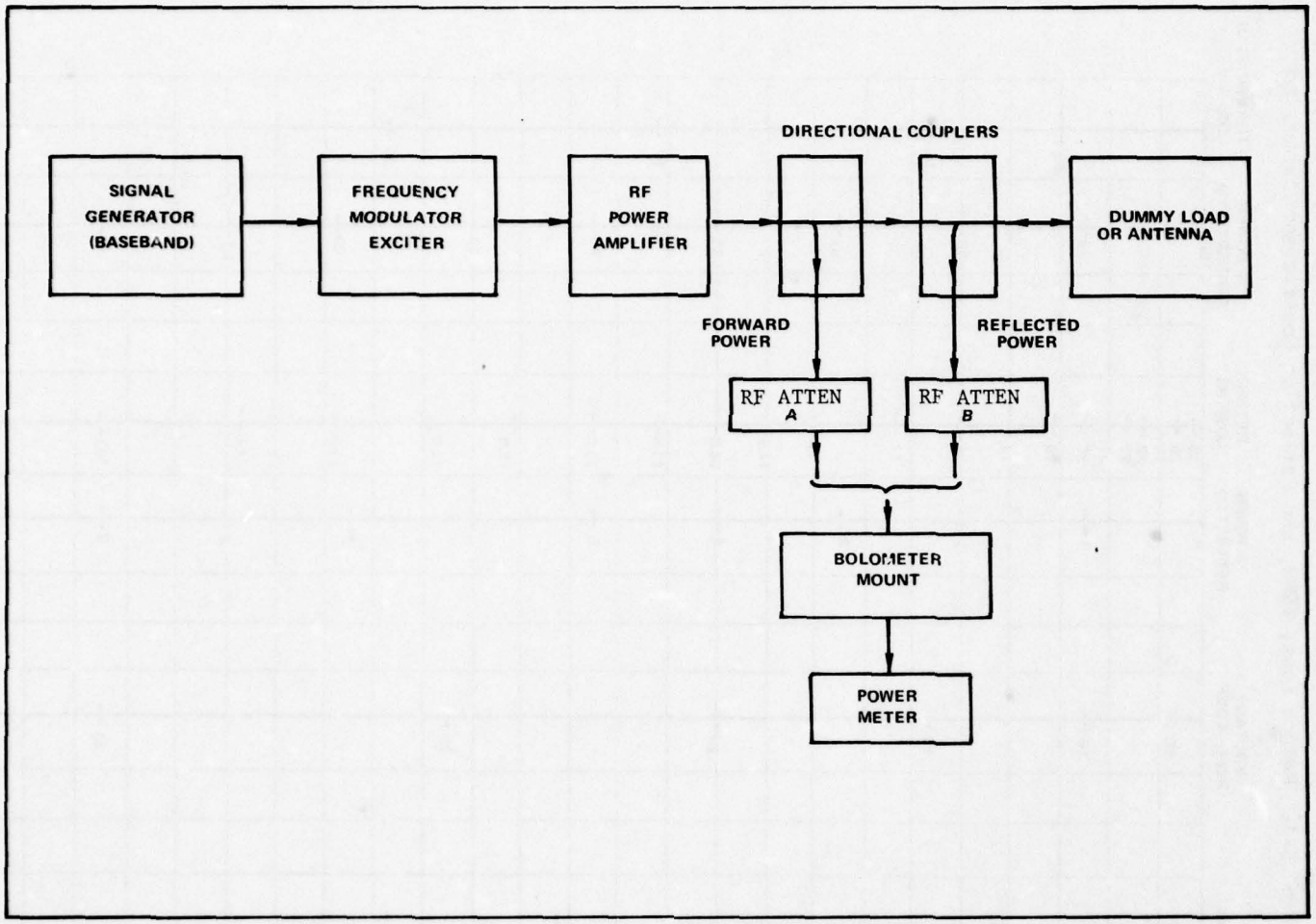
NOTE: If a storage capability exists on the analyzer display, the photographic techniques are simplified. Multiple sweeps can be stored until a sufficiently smooth display is obtained.

5-5. DATA RECORDING AND ANALYSIS.

a. Photograph the analyzer sweep display and mount the photographs on figure 5-2 (DD Form 2093). Complete the data sheets as required and summarize the test results on figure 3-7 (DD Form 2091).

b. Remove the test equipment and restore the system to its normal configuration.

c. If the system being tested fails to meet specifications, notify the responsible activity of any required corrective actions.



CCP 702-11

Figure 5-1. RF transmission line test setup.

Table 5-1. Return Loss, VSWR, and Reflection Coefficient Conversion

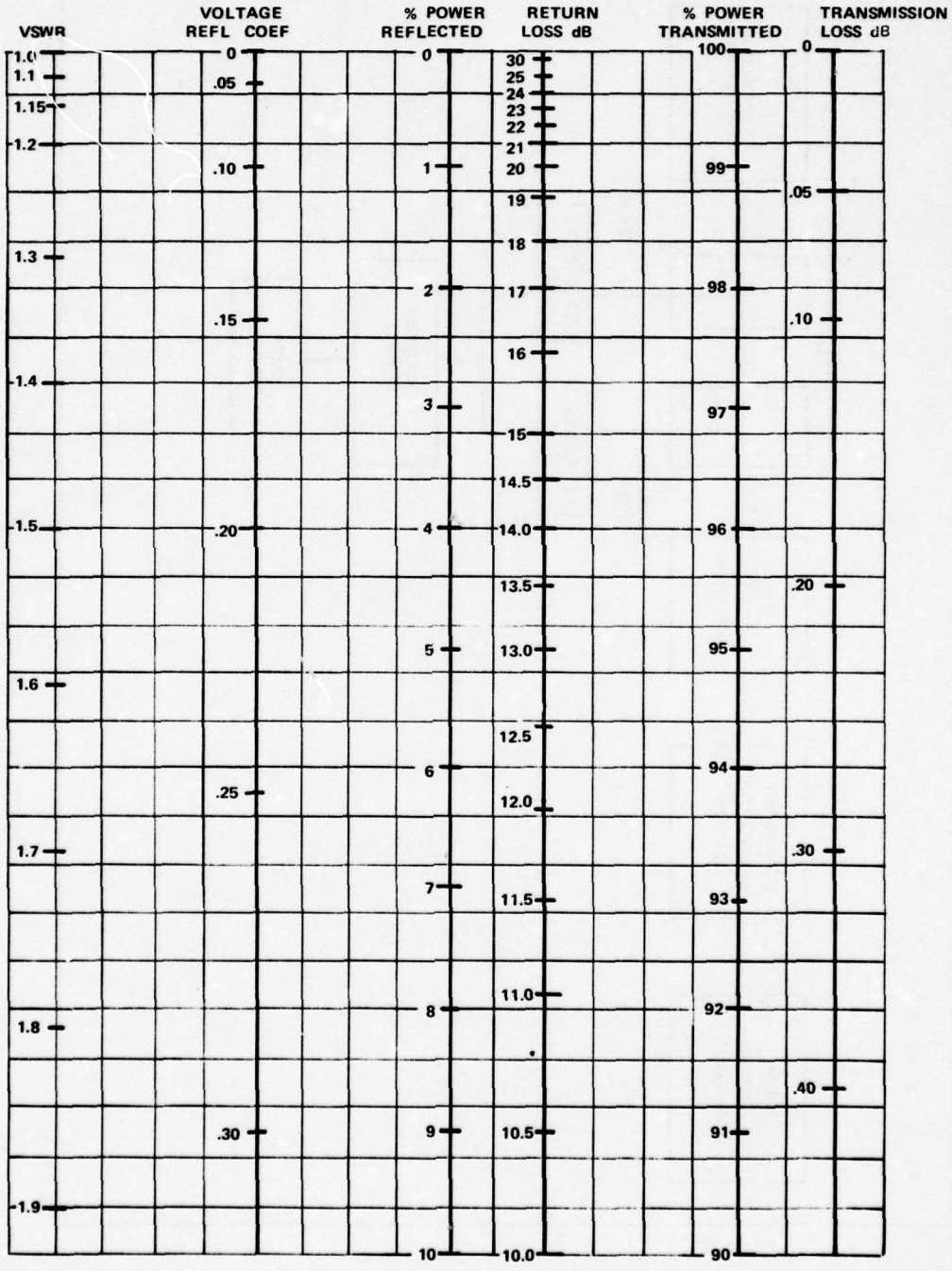
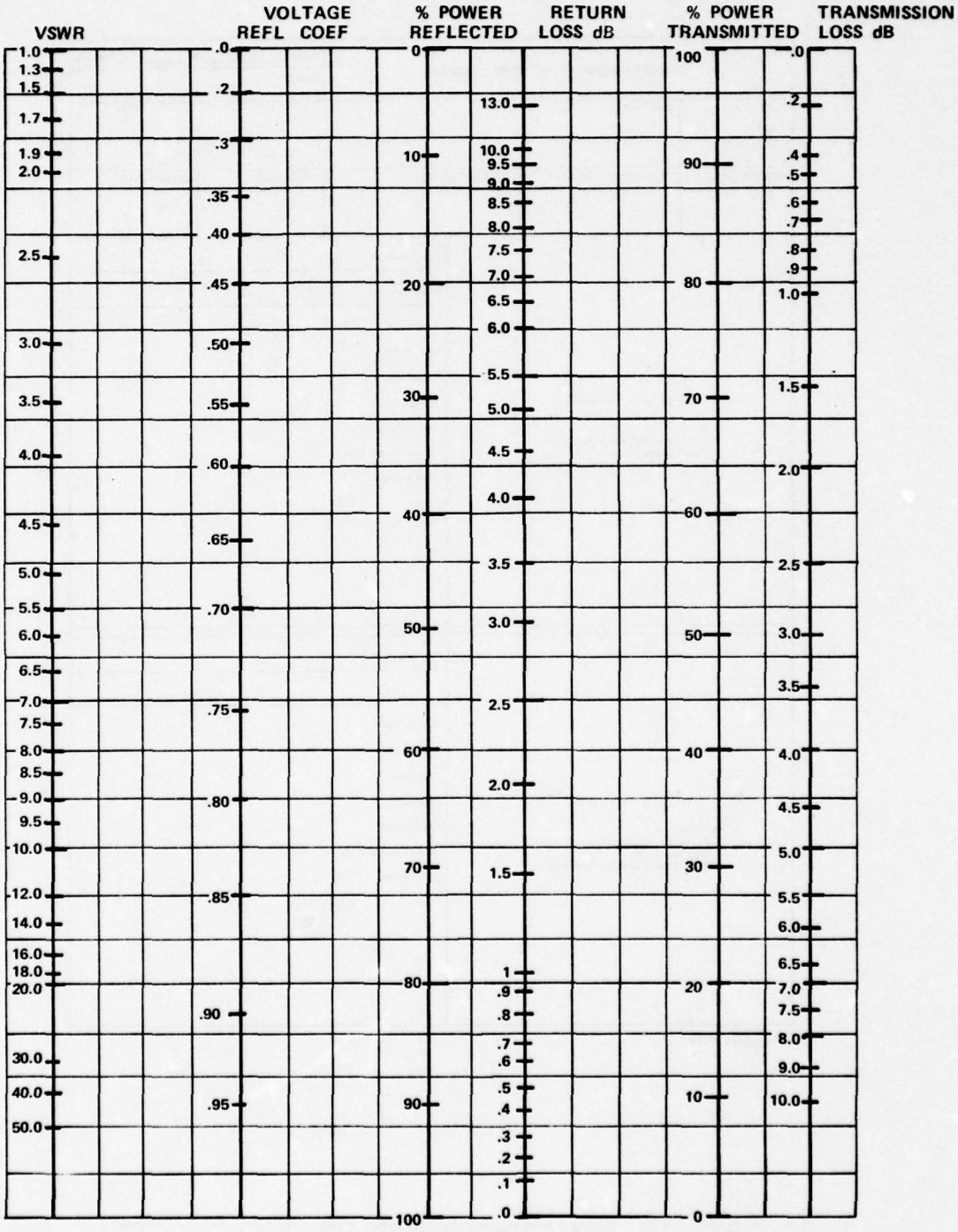


Table 5-1. Return Loss, VSWR, and Reflection Coefficient Conversion (continued)



GENERAL PURPOSE PHOTO RECORDINGS			PAGE_____OF_____PAGES DATE	
TEST NO. T_____	TEST TITLE:			
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

ATTACH PHOTO HERE Note: 1. Draw in tic marks to line up the photograph. 2. Indicate absolute response levels.	EQUIPMENT: SUBASSEMBLY: Bandwidth: Scan width: Dispersion: /division Video Filter: Center Freq.: Gain at Center Freq.: 3 dB Points: -Δ F + ΔF:
ATTACH PHOTO HERE Note: 1. Draw in tic marks to line up the photograph 2. Indicate absolute response levels.	EQUIPMENT: Bandwidth: Scan width: Dispersion /division Video Filter: Center Freq.: Gain at Center Freq.: 3 dB Points: -ΔF: +Δ F:

DD FORM 1 SEP 77 2093

Figure 5-2. General purpose photo recordings data sheet.

CHAPTER 6

RETURN LOSS VS DISTANCE PROFILE OF TRANSMISSION LINES AND ANTENNA SYSTEMS (DT-203)

6-1. GENERAL.

a. The purpose of this test is to obtain the return loss versus distance profile of the coaxial cable and waveguide from which the magnitude and location of discontinuities (faults, such as breaks, corrosion, and impedance irregularities) can be easily located.

b. Since the coaxial cable and waveguide in a transmission line system are usually relatively inaccessible throughout their run, it is desirable and at times necessary to determine their electrical condition from a convenient access point. This can be accomplished using the TDR technique (DT-201).

c. The TDR technique can be compared to a closed loop radar system in which an RF pulse burst is transmitted down the coaxial cable or waveguide transmission line, and the energy reflected back from any discontinuity or impedance variation is detected and displayed on the spectrum analyzer. Since there is a time delay between the incident and reflected signals and the sweep oscillator is rapidly changing frequency, the crystal detector will see two slightly different frequencies. This frequency difference is proportional to the oscillator sweep rate and to the distance to the discontinuity. In other words, the distance to a discontinuity determines the time that it takes for the reflected energy to return to the (reference) detector. The amplitude of the reflected signal is proportional to the reflection coefficient (return loss) of the discontinuity.

d. This test is similar to DT-202 except that the HP 5340 is specified. Either procedure will provide satisfactory results when properly performed.

e. This test is primarily a diagnostic aid by which to locate faults in a transmission line when return loss measurements are not within specifications. However, it may be used by installer or quality assurance personnel as directed.

f. The test may be performed at any or all of the test points shown in figure 6-1. These test points are defined as follows:

TP-1 - Klystron output.

TP-2 - Transmitter output port to the diplexer or circulator.

TP-3 - Antenna port of the diplexer/circulator.

TP-4 - Window of the feedhorn. This is the last physical point in the transmission network, the actual point of departure into free space.

TP-5 - Receiver output port of the circulator.

TP-6 - Receiver input port.

TP-7 - Nondiplexed waveguide that runs to the nondiplexed receiver.

TP-8 - Receiver output port of the diplexer.

TP-9 - Receiver input from the diplexer.

Other test points may be available such as between filter units, isolators, and other interconnecting points. When performing the test, personnel must ensure that the test point at which the measurements are made are fully identified in the test data.

6-2. SPECIFICATIONS.

a. The following criteria applies to the return loss versus distance profile of transmission lines and antenna systems. (MIL-STD-188-313)

(1) The input to the RF transmitter shall exhibit a return loss of 26 dB over the measurement bandwidth, centered on 70 MHz.

(2) The return loss, as measured toward the RF interface point, with all RF transmitting equipment installed and the RF interface point terminated in its characteristic impedance, shall not be less than 26 dB over the measurement bandwidth, centered on the assigned frequency.

(3) The return loss toward the antenna within a discrete frequency block (350 to 8400 MHz) shall not be less than 26 dB.

(4) The return loss toward the antenna within a discrete frequency block (1700 to 15,000 MHz) shall not be less than 28 dB.

(5) The return loss when measured at the RF interface point toward the receiver shall not be less than 32 dB over the measurement bandwidth, centered on the assigned frequency.

NOTE: The specifications stated in subparagraph a above do not directly apply to this test; however, they have been included as information to be used when measuring the level of any discontinuity and as a basis for comparison.

b. The VSWR (AN/FRC-162) looking into the RF interface point from the antenna feedline shall not be more than 1.05:1 (32-dB return loss) over a 15-MHz band, centered on the transmit and receive carrier frequencies. (SCCC-73017)

c. The VSWR (AN/FRC-( )) looking into the RF interface point from the antenna feedline shall not be more than 1.3:1 over a 20-MHz band, centered on the transmit and receive carrier frequencies. The radio shall provide specified performance when the antenna feedline presents a VSWR of 1.5:1 at any phase angle. (CCC-74049)

NOTE: Although the terminology in subparagraphs b and c above (VSWR) is referred to as return loss in the document cited, the criteria applies.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

6-3. TEST EQUIPMENT REQUIRED.

a. RF sweep generator HP 8620C.

b. Frequency counter HP 5340.

c. Dual directional coupler.

d. Reflectometer test set HP 8326A.

e. Spectrum analyzer HP 141T.

f. Crystal detector HP 423A.

g. Power splitter HP 11667A.

h. Connectors, adapters, terminations, and power splitter as required. See appendix A for additional hardware items.

6-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 6-2 and allow approximately 30 minutes for warmup and stabilization. Refer to figure 6-1 for the various test points at which this test can be performed.

b. Set the controls on the test equipment as follows:

RF SWEEP GENERATOR HP 8620C

RF output select switch..... Off.

NOTE: This switch should remain in the off position when the output is connected to the system under test to preclude interference with the system.

External automatic level control (ALC)..... Adjust to ensure adequate gain for the correct input leveling.

SPECTRUM ANALYZER HP 141T
(with HP 8556A LF plug-in)

Frequency..... 0 to 30K.

Scan width..... 200 Hz or zero pulse and return pulse position if small multiples of the fundamental calibration distances are to be used.

Scan width (per division)..... 100 Hz with red knob set to zero.

Input select switch..... dBm/50 ohms.

Input level..... -10 dBm, then set the variable control to midrange.

NOTE: This level may be adjusted to as much as -60 dBm.

Bandwidth..... 100 Hz.

SPECTRUM ANALYZER HP 141T
(with HP 8552( ) IF plug-in)

Scan time (per division)..... 0.1 second or as desired for a convenient display.

Logarithmic reference level..... 0 or 10 dB with the vernier control counterclockwise.

Scan mode..... Internal.

Scan trigger..... Automatic.

Video filter..... 10 Hz.

c. For calibration and measurement setup, proceed as follows:

(1) Disconnect the RF input cable to the test set or the power splitter and connect the RF cable to the frequency counter as shown in figure 6-2.

(2) Turn the mode switch on the RF sweep generator to manual.

(3) Set the generator output counterclockwise to the desired center frequency of the system or device under test.

(4) Turn the RF output switch on the RF sweep generator on and adjust the RF level control for an adequate level so that the frequency can be measured on the frequency counter.

(5) Once the exact frequency has been established with the frequency counter, return the RF output control to the full counterclockwise position and turn the output switch to off.

(6) Disconnect the RF cable from the frequency counter input and reconnect it to the test set or the power splitter input.

(7) Turn the RF output switch on and adjust the power output control until the unleveled light goes off. Ensure that the unleveled light is out at all times.

(8) Turn the storage select switch to the standard storage mode with minimum persistence and intensity to provide a convenient display.

(9) Adjust the IF plug-in (coarse/fine) to position the display midway on the face of the spectrum analyzer.

d. To calibrate for distance measurements, proceed as follows:

(1) Disconnect the input cable to the LF plug-in and adjust the zero adjust control to aline the local oscillator feedthrough pulse on the second vertical graticule from the left as shown in figure 6-3. This pulse will represent the zero distance calibration starting point.

(2) Connect a known length of cable to the RF output on the test set or the power splitter (suggest 6- or 10-foot length).

NOTE: If the LF plug-in drifts, aline the zero pulse to the desired vertical starting point for the final calibration.

(3) Reconnect the LF input cable to the LF plug-in and ensure that the RF output from the sweep generator is set for proper leveling operation.

(4) Adjust the logarithmic reference level and vernier control to keep at least three-quarters of the vertical scale level. Slightly vary the ΔF control to peak the return from the shorted test cable. The return should be peaked (maximum) with minimum interference.

(a) The setting of the bandwidth control on the LF plug-in will have an effect on the peak definition, and it may be found that the 100- or 300-Hz position will provide the best results.

(b) The input attenuator on the LF plug-in may be varied to obtain the best results when adjusting the ΔF control for a peak return.

(5) After achieving the best peak return, adjust the logarithmic/reference level on the LF plug-in for alinement of the first peak to the right of the zero pulse calibration point on the top graticule.

(6) Connect a series attenuator (between the cable end and the short) to the end of the calibrated length of cable.

NOTE: When subparagraphs (1) through (6), above, are completed, the sweep display should move down the required number of divisions. If a distance per division of less than one major division is required, proceed with subparagraphs (7) and (8), below.

(7) Increase the distance per division using the scan width per division control as a multiplier. The multiplication factor of X2, X5, X10, etc., may be used as desired.

(8) If distances of 18, 20, or 24 feet per division are required, start the scan width on the 100- or 200-Hz position. If shorter distances are desired, a scan width of 200 or 500 Hz can be initially selected to narrow the pulse for better calibration.

NOTE: The propagation velocity of the media being tested must be compared to the calibration cable being used. If they are different, try to ensure that the calibration is as accurate as possible. The optimum would be for the velocity factor to be the same. If waveguide is being tested, then a known length of waveguide with its far end shorted should be used as the calibrating device.

(9) Verify that the zero pulse is alined correctly and recheck the calibration.

(a) Any adjustment of the ΔF control or the time vernier will require recalibration.

(b) If an increase in the distance being observed is desired, the scan width control can be changed to the appropriate multiplier.

(10) For convenience, set the counter gate time to give a direct readout in feet (100-Hz resolution) or tenths of feet at 10-Hz resolution. The test set should now be calibrated in both distance and return loss.

(11) Read the distance in feet from the test port, and measure the return loss in dB from the analyzer display.

e. To measure a device, proceed as follows:

(1) Remove the short from the test cable and connect the device to be tested as shown in figure 6-1. The display will now be a direct readout of return loss versus distance.

(2) To change the distance scale, select the appropriate scan width on the spectrum analyzer. For example, to measure discontinuities from 0 to 500 feet from the test port, select a scan of 0 to 50 kHz (100 Hz per foot). The 0 to 100 frequency scan mode on the spectrum analyzer permits the selection of preset scans from zero distances without returning.

(3) For an expanded display of any portion of the system under test, tune the spectrum analyzer to the area of interest using the frequency dial. Switch to the scan width per division mode, and the selected portion becomes the center portion of the spectrum displayed. The scan width may be changed for any desired resolution.

(4) For increased amplitude resolution, use the 2-dB-per-division display. Switching to 2 dB per division, the zero graticule line will still represent 0-dB return loss. The display will be from 0- to 26-dB return loss.

6-5. DATA RECORDING AND ANALYSIS.

a. Photograph the test results and mount the photographs on figure 5-2 (DD Form 2093).

b. Ensure that all pertinent information is recorded on the data sheet and summarize the test results on figure 3-7 (DD Form 2091).

c. Remove all test equipment and restore the system to its normal configuration.

d. Note any anomalies in the cable or waveguide system and notify the responsible activity of any required corrective actions.

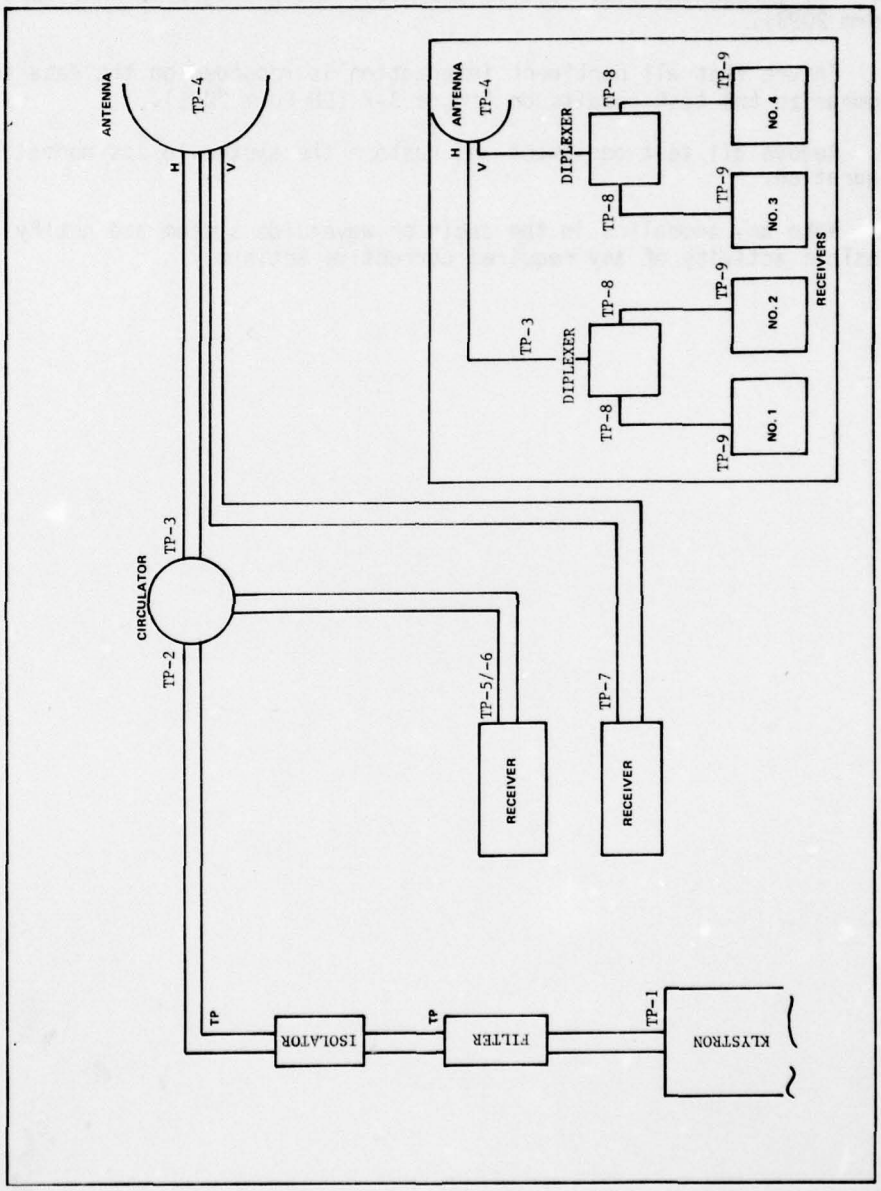


Figure 6-1. Typical antenna test points.

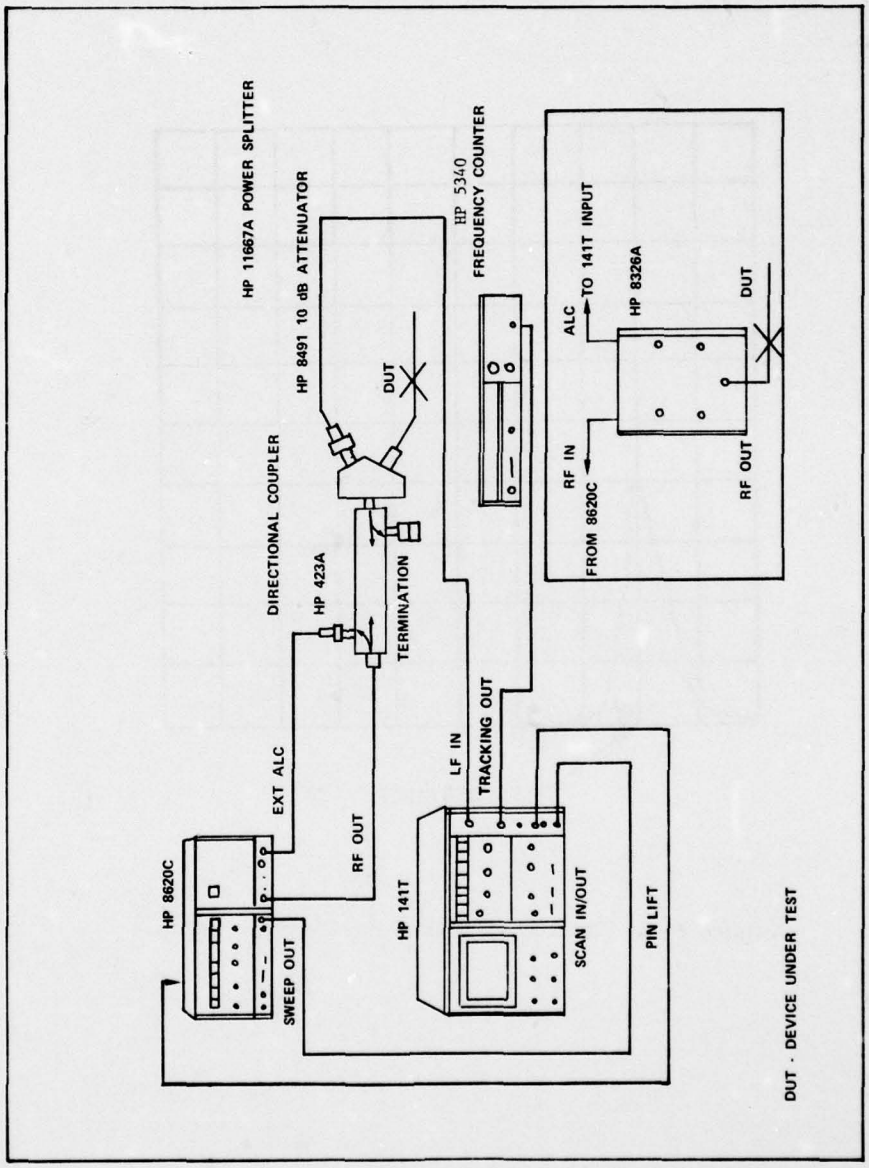


Figure 6-2. Return loss vs distance test setup.

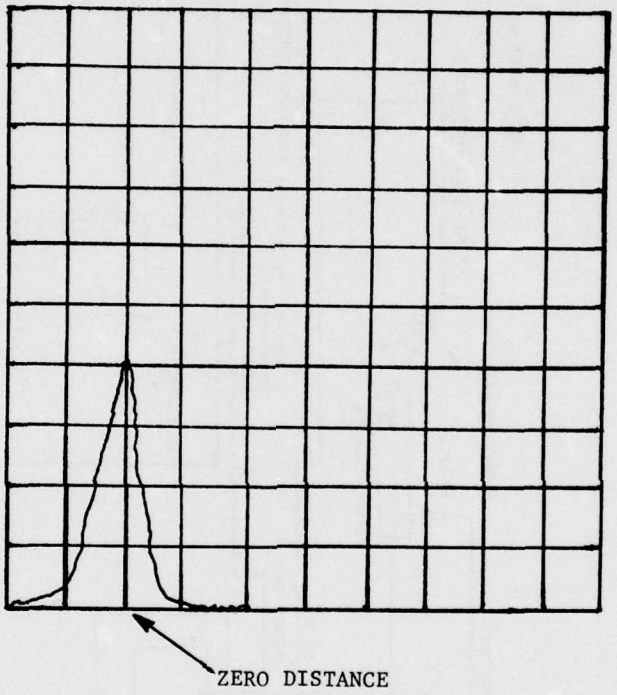


Figure 6-3. Typical distance calibration pulse.

CHAPTER 7

INSERTION AND RETURN LOSS (AUDIO METHOD) (DT-204)

7-1. GENERAL.

a. The purpose of this test is to measure the insertion and return loss of the antenna feed system to determine if the system conforms to specifications.

b. This test is similar to those described in the preceding chapters, except that the HP 5340 frequency counter is used. Either procedure will provide satisfactory results when properly performed.

c. The spectrum analyzer which has a variable persistence display of the measured signal at any sweep speed and the RF sweep generator are the main units used for the test. These items have been standardized as preferred items on the USACC PIL.

d. The wide frequency range of the spectrum analyzer makes it possible to perform sweep measurements of return loss greater than 40 dB (1.02:1 VSWR) in the linear mode.

e. Figure 6-1 is a typical drawing of a wideband antenna feed system since the accessible test points may vary from installation to installation. For the purpose of illustration and as a means of identification, selected test points are designated in figure 6-1. For definitions of these test points, see paragraph 6-1f. Other test points may be available such as between filter units, isolators, and other interconnecting points. When performing the test, personnel must ensure that the test points are fully identified in the test data.

f. This test may be performed by installer or quality assurance personnel as directed. It may also be used to verify that contractor EF&I systems conform to the specifications contained in the standard engineering plan or contract specifications.

7-2. SPECIFICATIONS.

a. The following criteria applies to insertion and return loss (audio method). (MIL-STD-188-313)

(1) The input to the RF transmitter shall exhibit a return loss of 26 dB over the measurement bandwidth, centered on 70 MHz.

(2) The return loss, as measured toward the RF interface point, with all RF transmitting equipment installed and the RF interface point terminated in its characteristic impedance, shall not be less than 26 dB over the measurement bandwidth, centered on the assigned frequency.

(3) The return loss toward the antenna within a discrete frequency block (350 to 8400 MHz) shall not be less than 26 dB.

(4) The return loss toward the antenna within a discrete frequency block (1700 to 15,000 MHz) shall not be less than 28 dB.

(5) The return loss when measured at the RF interface point toward the receiver shall not be less than 32 dB over the measurement bandwidth, centered on the assigned frequency.

NOTE: The specifications stated in subparagraph a above do not directly apply to this test; however, they have been included as information to be used when measuring the level of any discontinuity and as a basis for comparison.

b. The VSWR (AN/FRC-162) looking into the RF interface point from the antenna feedline shall not be more than 1.05:1 (32-dB return loss) over a 15-MHz band, centered on the transmit and receive carrier frequencies. (SCCC-73017)

c. The VSWR (AN/FRC-( )) looking into the RF interface point from the antenna feedline, shall not be more than 1.3:1 over a 20-MHz band, centered on the transmit and receive carrier frequencies. The radio shall provide specified performance when the antenna feedline presents a VSWR of 1.5:1 at any phase angle. (CCC-74049)

NOTE: Although the terminology in subparagraphs b and c above (VSWR) is referred to as return loss in the document cited, the criteria applies.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

7-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter HP 5340.

b. RF sweep generator HP 8620C.

c. Spectrum analyzer HP 141T.

d. Oscilloscope camera TEK C-27/C-30 or HP 197.

e. Adapters, connectors, and detectors as required. Since most of these items are frequency limited, see appendix A for selection of appropriate item and additional hardware.

7-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 7-1 and allow approximately 30 minutes for warmup and stabilization.

b. Set the controls on the test equipment as follows:

RF SWEEP GENERATOR HP 8620C

Mode switch	Automatic.
Trigger select	Internal.
Time select	10 seconds with fine adjust control centered.
Band select	Frequency band of interest.
ΔF-continuous wave (CW)	Depending on the desired sweep width or the start-stop mode of operation.
Marker select	Off.
CW vernier	X1.
ΔF vernier	X1, adjust for desired sweep.
Blanking (rear apron)	Off.
External amplitude modulation (AM) (rear apron)	Off.
Z-axis (rear panel)	On.

RF PLUG-IN HP 8621B

RF output	Off.
External ALC	Adjust to ensure adequate gain for the correct input leveling.
ALC gain	Midrange.

NOTE: Use the ALC external position when the dual directional coupler is used.

SPECTRUM ANALYZER HP 141T
(with HP 8556A LF plug-in)

Frequency	0 to 30K.
Frequency fine tune	5 kHz on-scale.
Bandwidth	100 Hz.
Scan width (per division)	100 Hz with red knob set to zero.

Input level..... -10 dBm, then set the variable control to midrange.

NOTE: This level may be adjusted to as much as -60 dBm.

Input select..... dBm/50 ohms.

20K marker..... Out.

SPECTRUM ANALYZER HP 141T
(with HP 8552( ) IF plug-in)

Baseline clipper..... Fully counterclockwise.

Video filter..... Position as desired for a clean display.

Scan mode..... External.

Scan time..... As desired.

Scan trigger..... As desired.

Logarithmic reference level..... 10 dB.

SPECTRUM ANALYZER HP 141T
(display section)

Intensity..... As desired.

Storage select..... Store or conventional as desired for display.

RF sweep generator output switch..... On.

Logarithmic level control..... Adjust to position display midway on the face of the display unit.

c. For the calibration and measurement setup, proceed as follows:

(1) Connect a short to the test port of the dual directional coupler and calibrate the vertical (return loss) scale by adjusting the IF plug-in to place the sweep on the top graticule of the display unit. Use the maximum possible gain on the LF plug-in for the best dynamic range.

(2) Connect the RF output cable from the dual directional coupler to the frequency counter. Turn the mode switch on the RF sweep generator to manual. A single spot should be displayed on the spectrum analyzer display unit. Set the frequency of interest (CW frequency) at the center point of display, or set the start-stop mode for each end of the desired frequency bandwidth.

(3) For the ΔF-CW operation, set the CW center frequency after setting the desired ΔF sweep range. The frequency accuracy can be checked by manually spotting the CW frequency on the display and measuring the frequency with the counter. Check each side of the display by manually changing the generator output frequency while measuring with the counter. Also determine the actual frequency per division as determined from the display unit.

(4) Return the RF sweep generator mode switch to automatic and reconnect the RF output cables to the directional coupler.

(5) Connect a series attenuator between the reflection port and the crystal detector as shown in figure 7-1.

(6) Increase the attenuation to determine if the sweep moves down the required number of divisions (10, 20, 30, 40 dB), to verify that the power input level allows for square law detector operation. That is, a 3-dB change in input power gives a 6-dB change in output voltage. If this requirement is not met, the following will be required.

(a) To adjust for square law operation, place the input level (fine control) of the LF plug-in to midrange.

(b) Adjust the power output control until the unleveled light goes off. Recheck the calibration with the attenuator connected between the reflection port and the crystal detector.

(c) If the correct level change in dB is not observed, reshort the output of the directional coupler, remove the attenuation, and slightly reduce the power output level. Recalibrate the vertical sweep for the top graticule alinement.

(d) Recheck the vertical calibration by using a known amount of attenuation. Continue this procedure until the correct downward deflection is obtained.

NOTE: Once the calibration has been verified, the test equipment is ready for actual measurements. Calibration lines in dB steps can be readily established on the variable persistence cathode ray tube (CRT) and will provide for accurate identification of the 3- and 6-dB points.

d. To measure return loss/insertion loss, proceed as follows:

(1) Connect the output port of the directional coupler to the device under test and photograph the results as observed on the display unit.

(2) Mount the photographs on figure 5-2 (DD Form 2093).

7-5. DATA RECORDING AND ANALYSIS.

a. Ensure that all pertinent information is recorded on the data sheet and summarize the test results on figure 3-7 (DD Form 2091).

b. If desired, an X-Y recorder can be used for recording the return loss in addition to the photographic display. This data will be recorded on figure 3-4 (DD Form 2094).

c. Some possible causes of poor return loss performance of the transmission line and antenna system are:

(1) Loose or poor connections.

(2) Corrosion of waveguide or cables.

(3) Dents or kinks in the waveguide.

(4) Moisture.

(5) Misalined flanges.

d. If the transmission line fails to meet specifications, notify the responsible activity of the required corrective actions.

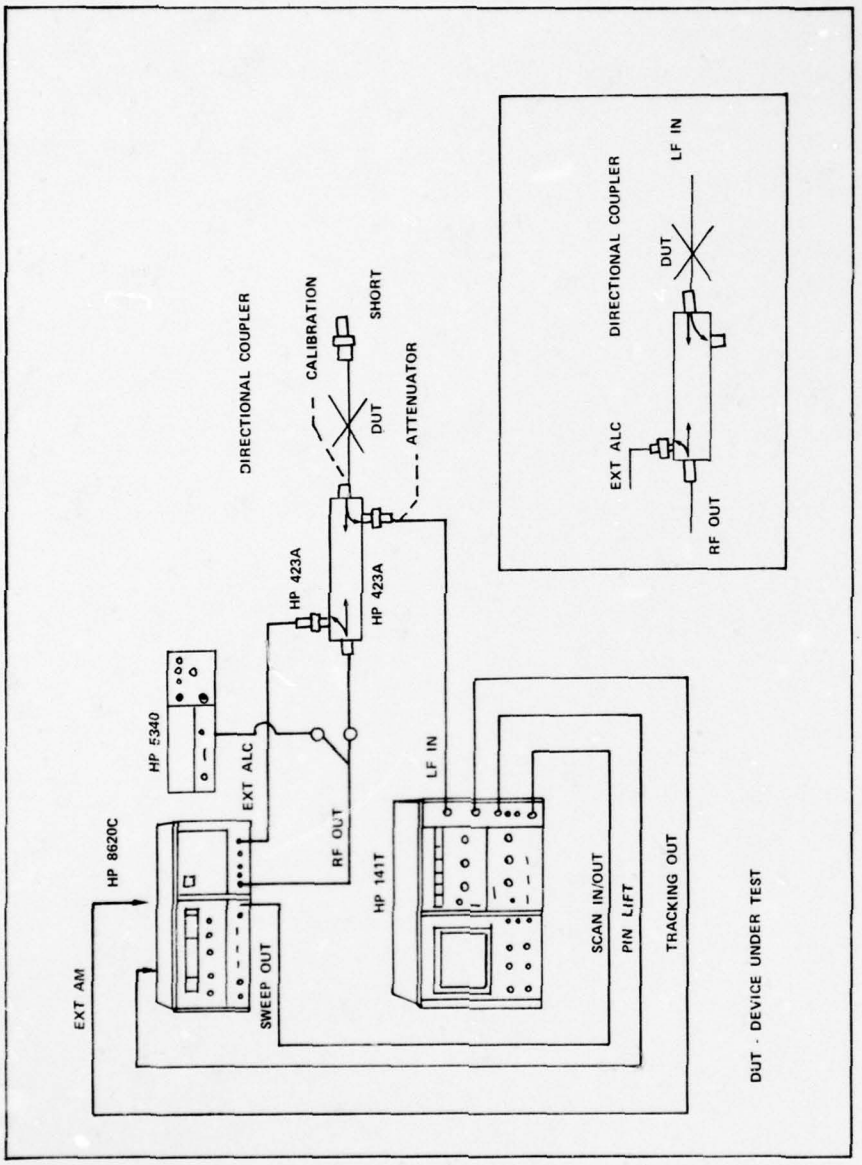
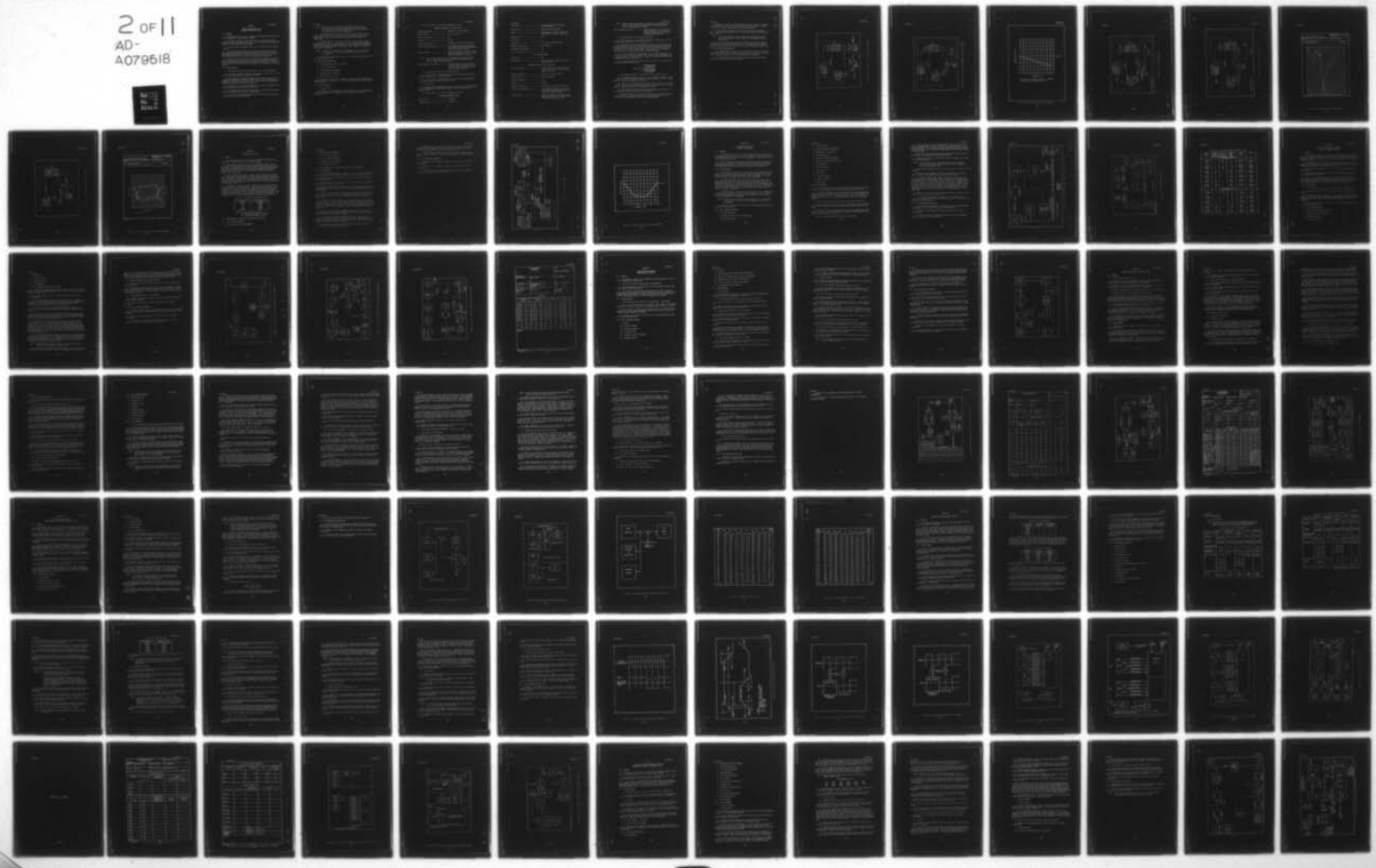
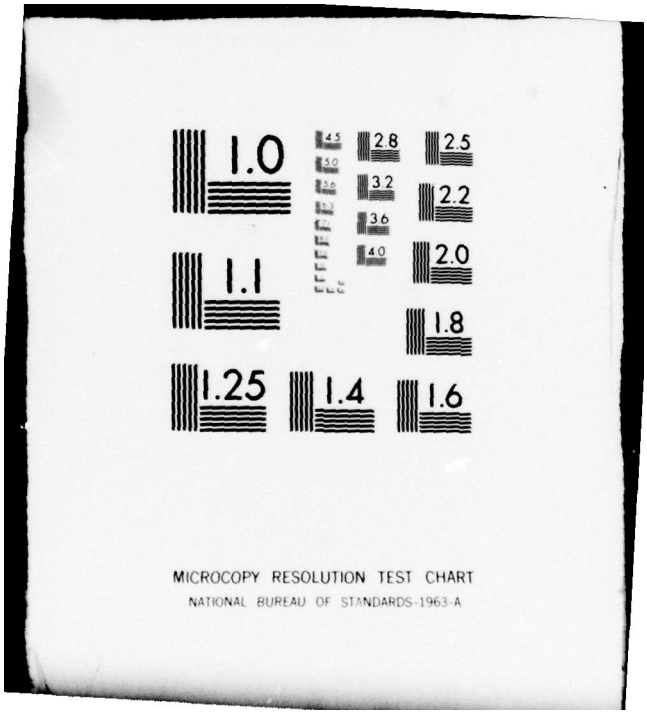


Figure 7-1. Insertion loss (audio method) test setup.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

2 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CHAPTER 8

INSERTION AND RETURN LOSS (AUTOMATIC METHOD) (DT-205)

8-1. GENERAL.

a. The purpose of this test is to measure the insertion and return loss of RF transmission lines and antenna systems.

b. This test is similar to that described in the preceding chapters except that the HP 8755B test set is used. Either procedure will provide satisfactory results when properly performed.

c. This test may be performed at any or all of the test points shown in figure 6-1.

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

e. With this test it is possible to determine the magnitude and distance to any discontinuity within the transmission line and antenna system when performing diagnostic testing and troubleshooting of the system. The simultaneous display of insertion and return loss permits rapid analysis of the test results.

8-2. SPECIFICATIONS.

a. The following criteria applies to return loss. (MIL-STD-188-313)

(1) The input to the RF transmitter shall exhibit a return loss of 26 dB over the measurement bandwidth, centered at 70 MHz.

(2) The return loss, as measured toward the RF interface point, with all transmitting equipment installed and the RF interface point terminated in its characteristic impedance, shall not be less than 26 dB over the measurement bandwidth, centered on the assigned frequency.

(3) The return loss toward the antenna within a discrete frequency block (350 to 8400 MHz) shall not be less than 26 dB.

(4) The return loss toward the antenna within a discrete frequency block (1700 to 15,000 MHz) shall not be less than 28 dB.

(5) The return loss when measured at the RF interface point toward the receiver shall not be less than 32 dB.

NOTE: The specifications stated in subparagraph a above do not directly apply to this test; however, they have been included as information to be used when measuring the level of any discontinuity and as a basis for comparison.

b. The VSWR (AN/FRC-162) looking into the RF interface point from the antenna feedline shall not be more than 1.05:1 (32-dB return loss) over a 15-MHz band, centered on the transmit and receive carrier frequencies. (SCCC-73017)

c. The VSWR (AN/FRC-( )) looking into the RF interface point from the antenna feedline shall not be more than 1.3:1 over a 20-MHz band, centered on the transmit and receive carrier frequencies. The radio shall provide specified performance when the antenna feedline presents a VSWR of 1.5:1 at any phase angle. (CCC-74049)

NOTE: Although the terminology in subparagraphs b and c above (VSWR) is referred to as return loss in the document cited, the criteria applies.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

8-3. TEST EQUIPMENT REQUIRED.

a. Frequency response test set HP 8755B.

b. X-Y recorder HP 7035.

c. RF sweep generator HP 8620C.

d. Frequency counter HP 5340.

e. Dual directional coupler.

f. Adapters and connectors as required. Since many of the components are frequency limited, see appendix A for selection of appropriate items and additional hardware.

8-4. TEST PROCEDURES.

a. Insertion Loss.

(1) Connect the test equipment as shown in figure 8-1 or 8-2 depending on the desired method and allow approximately 30 minutes for warmup and stabilization.

(2) Set the controls on the test equipment as follows:

FREQUENCY RESPONSE TEST SET HP 8755B

Channel pushbuttons.....	Release for A and B channels.
Channel select.....	A or B as desired.
Offset calibration.....	Off.
Digital.....	Off-00.
dB/division select.....	10 dB/division vertical sensitivity.
Display position control.....	Push switch and adjust to aline the trace with the top reference graticule (screwdriver adjust control).
Display button.....	Push selected button and adjust output power of HP 8620C until trace is near reference graticule (fig. 8-3).

NOTE: Consider the coupling factor in determining the generator power level. Levels should not exceed 10 dBm or approximately one division below reference graticule.

Ratio pushbutton A/R, B/R.....	Select channel A or B for display. Turn the calibration selector on and adjust the level until the trace is alined with the reference.

(3) To measure insertion loss, proceed as follows:

(a) Turn the vertical sensitivity switch from 0.25 dB/division to fine adjust and then return it to 10 dB/division.

(b) Use the channel offset switches to position the trace calibration line applying the desired range of sensitivity.

b. Return Loss.

(1) Connect the test equipment as shown in figure 8-4 or 8-5 depending on the desired method and allow approximately 30 minutes for warmup and stabilization.

(2) Set the controls on the test equipment as follows:

RF SWEEP GENERATOR HP 8620C

Mode switch.....	Automatic.
Trigger select.....	Internal.

Time select.....	10 seconds with the fine adjust control centered.
Band select.....	Frequency band of interest.
ΔF-CW.....	Depending on the desired sweep width or the start-stop mode of operation.
Marker select.....	Off.
CW vernier.....	X1.
ΔF vernier.....	X1, adjust for desired sweep.
Blanking (rear apron).....	On, clockwise.
External AM (rear apron).....	Off.
Z-axis (rear panel).....	On.

RF PLUG-IN HP 8621B

RF output.....	Off.
Internal ALC.....	Adjust to ensure adequate gain for the correct output.

FREQUENCY RESPONSE TEST SET HP 8755B

Cable connections.....	From HP 8755B to the dual directional coupler (fig. 8-4) or the reflection bridge (fig. 8-5).
Channel pushbuttons.....	Release for A and B channels.
Channel select.....	A or B as desired.
Offset calibration.....	Off.
Digital.....	Off-00.
dB/division select.....	10 dB/division vertical sensitivity.
Display position control.....	Push switch and adjust to aline the trace with the top reference graticule (screwdriver adjust control).
Display button.....	Push selected button and adjust output power of HP 8620C until trace is near reference graticule (fig. 8-6).

NOTE: Consider the coupling factor in determining the generator power level. Levels should not exceed 10 dBm or approximately one division below reference graticule.

Ratio pushbutton A/R, B/R..... Select channel A or B for display. Turn the calibration selector on and adjust the level until the trace is alined with the reference.

(3) To measure return loss, proceed as follows:

(a) Turn the vertical sensitivity switch from 0.25 dB/division to fine adjustment and then return it to 10 dB/division.

(b) Remove the short from the directional coupler (fig. 8-4 or 8-5) and connect the output port of the directional coupler to the device under test. The channel offset dB switch can be adjusted to reposition the trace on the reference line for accurate measurement. Greater sensitivity than 10 dB/division can be selected to obtain a more accurate reference.

(c) The return loss can be read directly on the offset dB switches. If the trace is still below the reference line, add the amount (depending on sensitivity selected) of the offset switch setting. The return loss represents the VSWR of the device under test.

(d) To convert return loss to VSWR, refer to table 5-1 or calculate the value using the following formula:

$$VSWR = \frac{1 + \sqrt{\frac{\text{reflected power}}{\text{forward power}}}}{1 - \sqrt{\frac{\text{reflected power}}{\text{forward power}}}}$$

c. Simultaneous Recording or Display of Insertion and Return Loss.

(1) For frequency response, connect the test equipment as shown in figure 8-7 and allow approximately 30 minutes for warmup and stabilization. Set the controls on the test equipment as follows:

(a) Place a short on the output of the directional coupler and set channel A of the test set according to the procedures for return loss in paragraph 8-4a(2). Remove the short from the directional coupler.

(b) Once the power output from the RF sweep generator has been set, do not readjust during the insertion loss measurement.

(c) Connect detector B to the output port of the directional coupler and set up channel B of the test set according to paragraph 8-4a(2), above. Do not adjust the output power level of the RF sweep generator.

(d) Remove the crystal detector from the directional coupler and connect it to the 10-dB attenuator at the output of the device under test. Connect the directional coupler output port to the device under test.

(2) Simultaneous measurement of return and insertion loss can now be made. Place the channel B offset switch to -10 dB to offset the 10-dB loss of the attenuator.

NOTE: The 10-dB attenuator is used to provide a better match for the return loss measurement and to reduce the reflections caused by the detector.

(3) Using the storage mode, the dual display can be stored for analysis and display of the return and insertion loss. See figure 8-8 for a typical example of simultaneous return and insertion loss as observed on the test set.

8-5. DATA RECORDING AND ANALYSIS.

a. Mount photographs on figure 5-2 (DD Form 2093) or plot data on figure 3-4 (DD Form 2094) or both. Summarize the test results on figure 3-7 (DD Form 2091). Note any irregularities and pertinent points of interest.

b. If the device fails to meet specifications, notify the responsible activity of the required corrective actions.

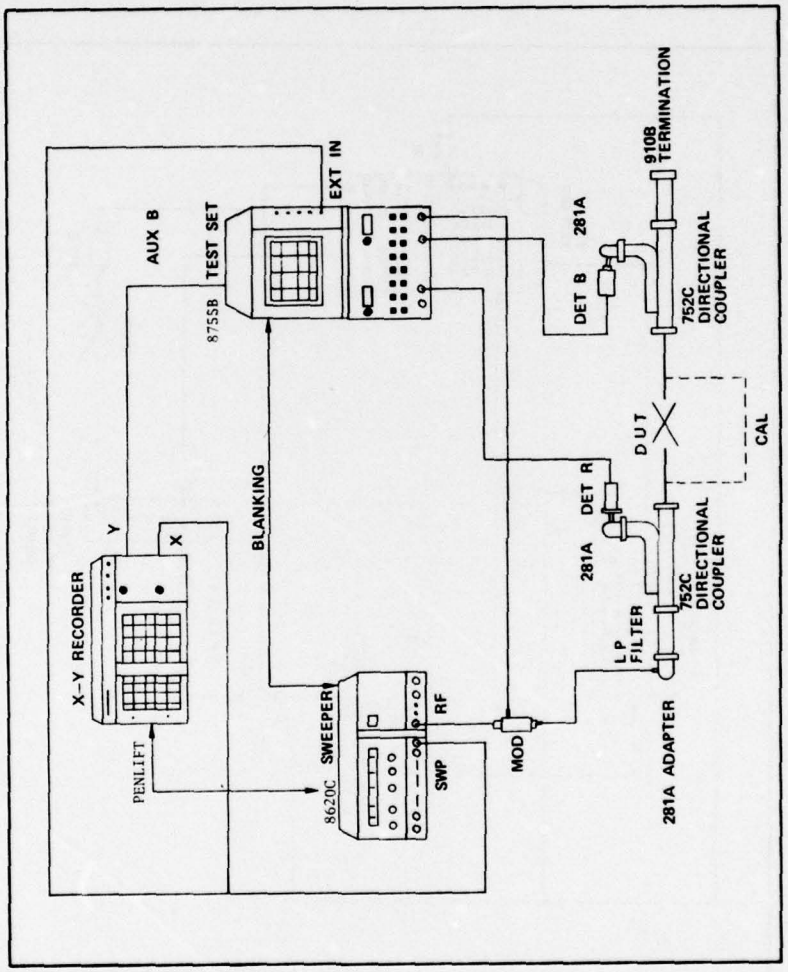


Figure 8-1. Insertion loss (X-Y recording) test setup.

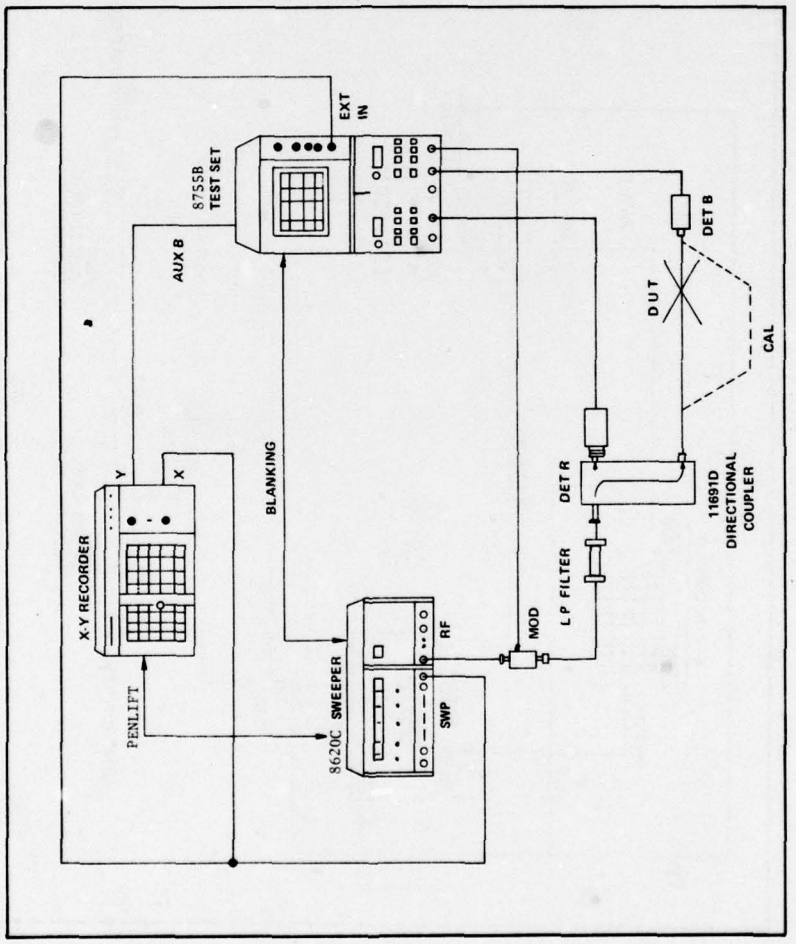
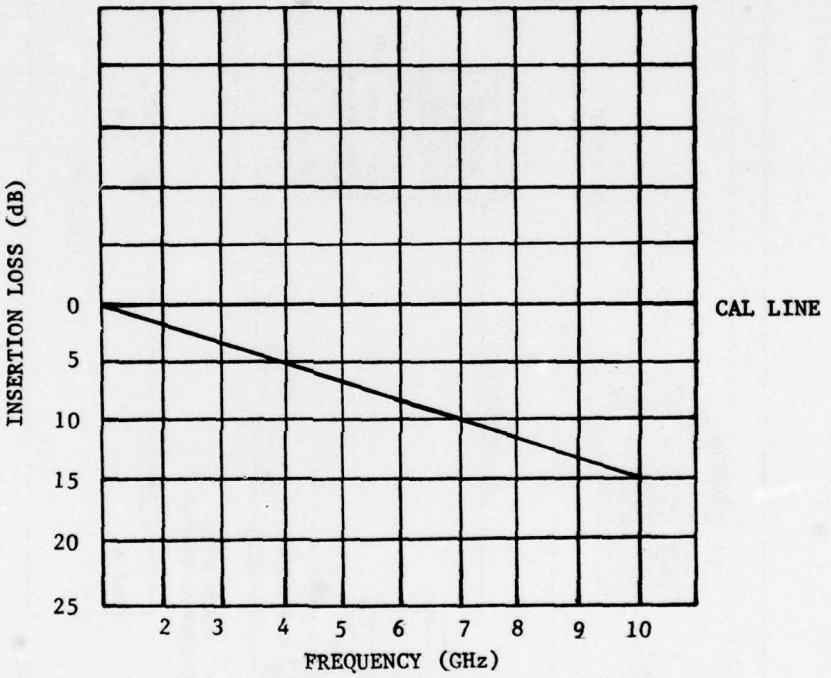


Figure 8-2. Insertion loss (photographic method) test setup.



Calibrated for 0 dBm at reference. Insertion loss at 4 GHz is approximately 5 dB.

Figure 8-3. Typical insertion loss measurement.

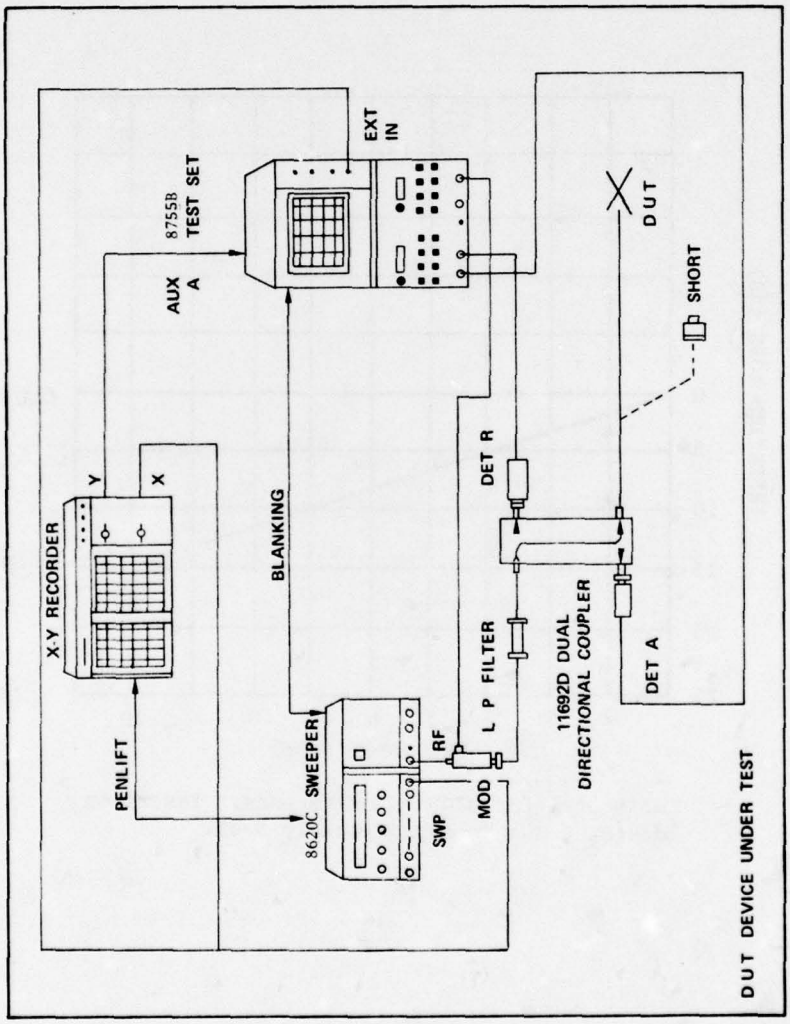


Figure 8-4. Return loss test setup.

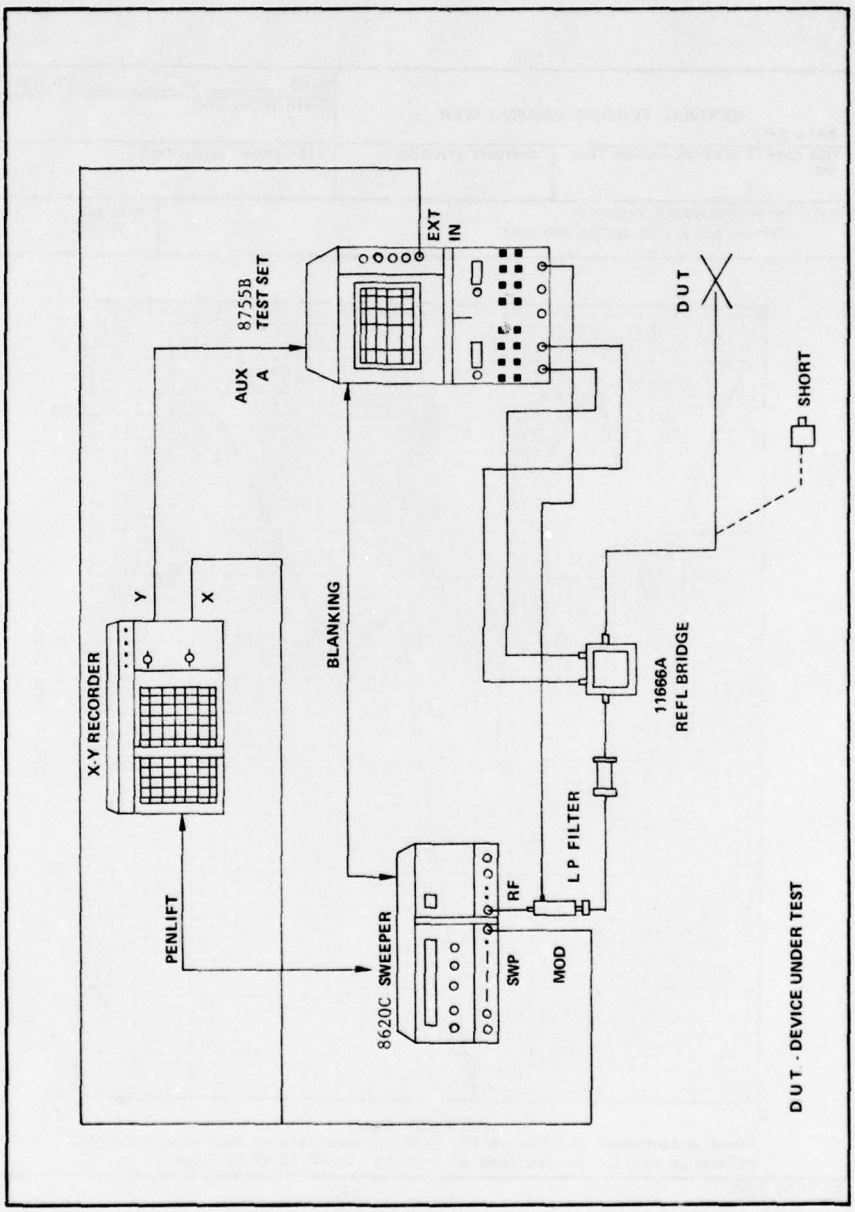


Figure 8-5. Frequency response test setup.

GENERAL PURPOSE GRAPH PAPER DATA SHEET			PAGE _____ OF _____ PAGES DATE (day, mo., year)
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE
TITLE OF PERFORMANCE PLOTTED Return Loss (Automatic Method)			TEST NO. DT-205



Sweep measurement calibrated for 0-dBm return loss at the logarithmic/ reference level. Return loss at 3.25 GHz is 40 dB (1.02 VSWR)

DD FORM 2094

Figure 8-6. Typical return loss measurement.

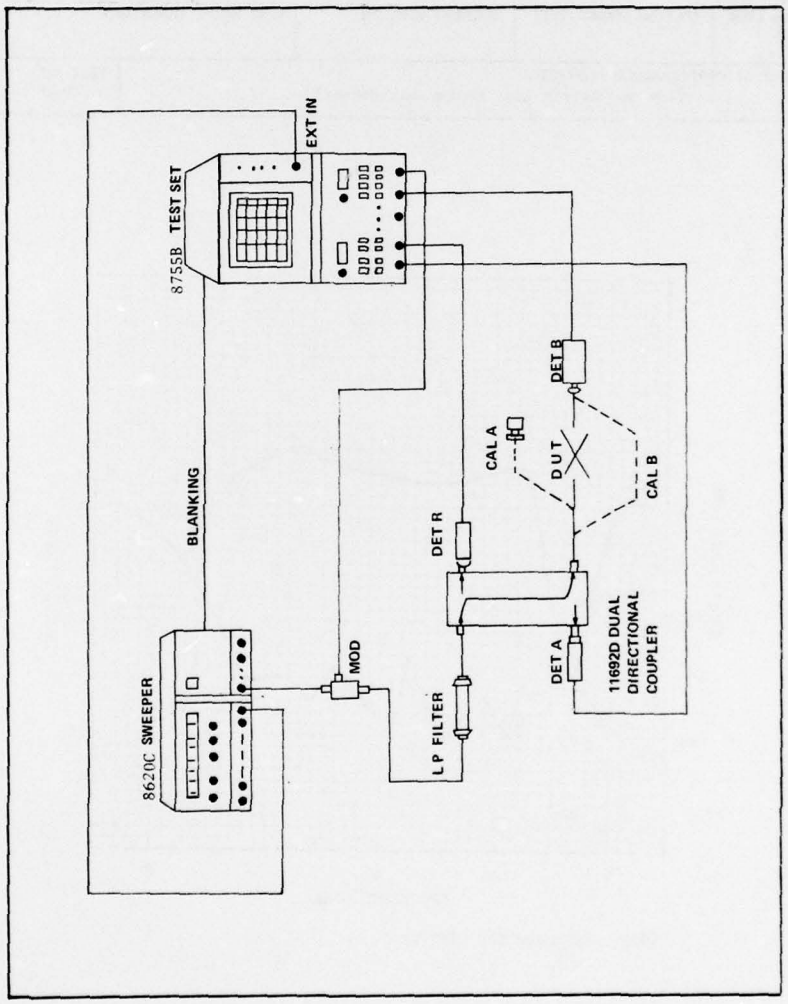
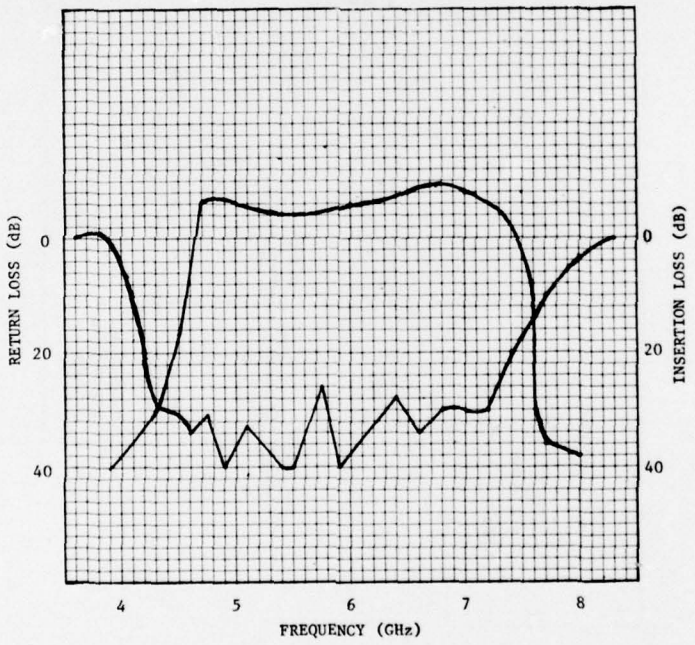


Figure 8-7. Insertion and return loss test setup.

GENERAL PURPOSE GRAPH PAPER DATA SHEET			PAGE_____ OF _____ PAGES DATE (day, mo., year)
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE
TITLE OF PERFORMANCE PLOTTED Insertion and Return Loss (Automatic Method)			TEST NO. DT-205



NOTE: Expanded for clarity.

DD FORM 2094

Figure 8-8. Typical insertion and return loss measurements.

CHAPTER 9

GROUP DELAY (DT-206)

9-1. GENERAL.

a. The purpose of this test is to provide a method for measuring the group delay in transmission lines and antenna systems.

b. When nonlinear phase shift occurs in transmission lines, filters, circulators, and other devices as a function of frequency, distortion occurs. Measurement of the group delay provides an indication of the nonlinear phase shift of the propagating wave. If the frequency phase shift through the transmission line is linear, the group delay will remain constant and the signal will be undistorted.

c. Swept frequency measurements of group delay can be quickly and accurately made over a frequency range of 1 MHz to 18 GHz using the vector voltmeter. The method consists of amplitude modulating a CW signal, transmitting it through the device under test, and then measuring the phase shift of the envelope. The group delay of the device under test will then be proportional to the envelope phase shift.

d. Modulating frequencies between 1 and 10 MHz can be used for small delay measurements. If a frequency of 2.778 MHz is used, group delay can be read directly in nanoseconds (nsec) per degree of phase shift on the vector voltmeter. For large group delay, measurement with a 20-kHz modulating frequency should be used. This will require bypassing the RF section of the voltmeter and inserting the signal using only the 20-kHz IF phase meter. The following table was extracted from Hewlett Packard Application Note 77-4.

Table 9-1. Group Delay Calibration Factor

Calibration Factor $t_d/\Phi e$	Modulation Frequency f_m (MHz)
0.5	5.555
1.0	2.778
1.5	1.852
2.0	1.389
139.0	0.020

NOTE: t_d = group delay in seconds.
Φe = envelope phase shift in degrees.
f_m = modulation frequency in Hz.

9-2. SPECIFICATIONS. As stated in manufacturer's manuals.

9-3. TEST EQUIPMENT REQUIRED.

a. RF sweep generator HP 8690B/8620C.

b. Oscillator HP 651B/654A.

c. X-Y recorder HP 7035B.

d. Vector voltmeter HP 8405A.

e. Frequency counter HP 5340A.

f. Oscilloscope TEK 475A

g. See appendix A for miscellaneous adapters and connectors.

9-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 9-1 without the device to be tested and allow approximately 30 minutes for warmup and stabilization.

b. Establish the modulating frequency on the oscillator as observed on the frequency counter.

c. Use the frequency range switch on the vector voltmeter to bracket the modulating frequency of the oscillator.

d. Adjust the start-stop sweep controls on the RF sweep generator for the desired frequency range, sweep selector for trigger, and sweep time between 10 and 100 seconds.

e. Adjust the RF sweep generator output power and the oscillator signal for maximum undistorted sine wave as detected by channel B of the vector voltmeter. This can be done by observing the channel B 20-kHz IF output on an oscilloscope.

f. Adjust the variable attenuator so that channels A and B are within 10 dB of each other. The phase accuracy of the vector voltmeter is best when the signals are approximately the same. If the test device has greater than 10 dB of gain or attenuation, the variable attenuator should be adjusted so that the difference in signal levels at channels A and B is minimum before and after calibration.

g. Calibrate the X-Y recorder sweep width by manually sweeping the RF sweep generator and calibrating the phase resolution using the phase zero and meter offset switch on the vector voltmeter.

h. Use the sweep control to drive the X-Y recorder X-axis and draw calibration lines for different settings of phase zero. When the device to be tested is inserted after calibration, group delay will be indicated by a more negative phase shift as shown in figure 9-2.

i. Use the phase output of the vector voltmeter to drive the Y-axis of the recorder and to display the group delay.

j. Connect the device to be tested as shown in figure 9-1, set the RF sweep generator to automatic sweep, and with the X-Y recorder energized, record the phase difference on figure 3-4 (DD Form 2094).

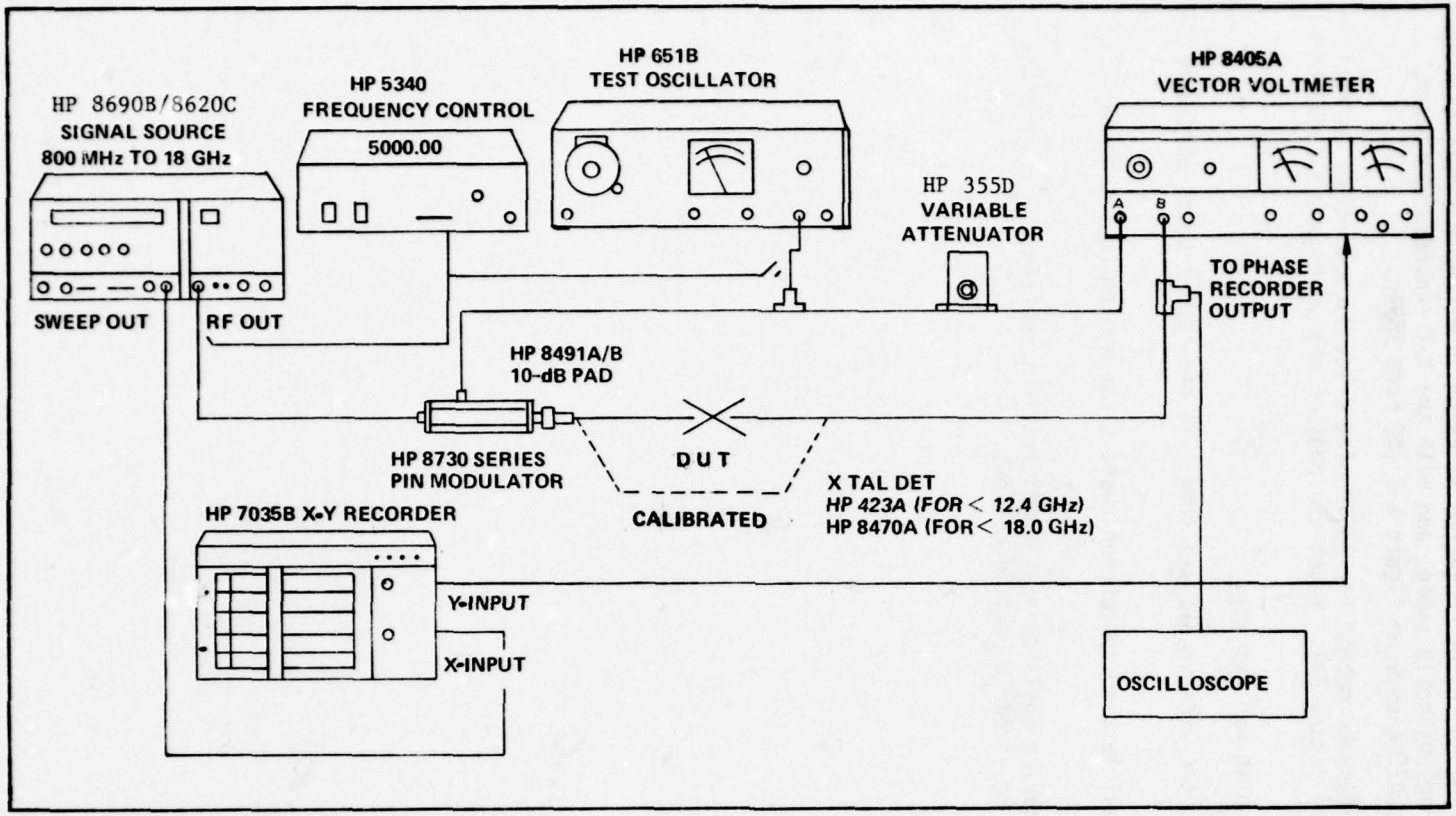
k. As an alternate method for collecting delay data, connect an oscilloscope as shown in figure 9-1. Mount the photographs on figure 5-2 (DD Form 2093).

9-5. DATA RECORDING AND ANALYSIS.

a. Complete the data sheets and summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the device fails to meet specifications, notify the responsible activity of the required corrective actions.



CCP 702-11

Figure 9-1. Group delay test setup.

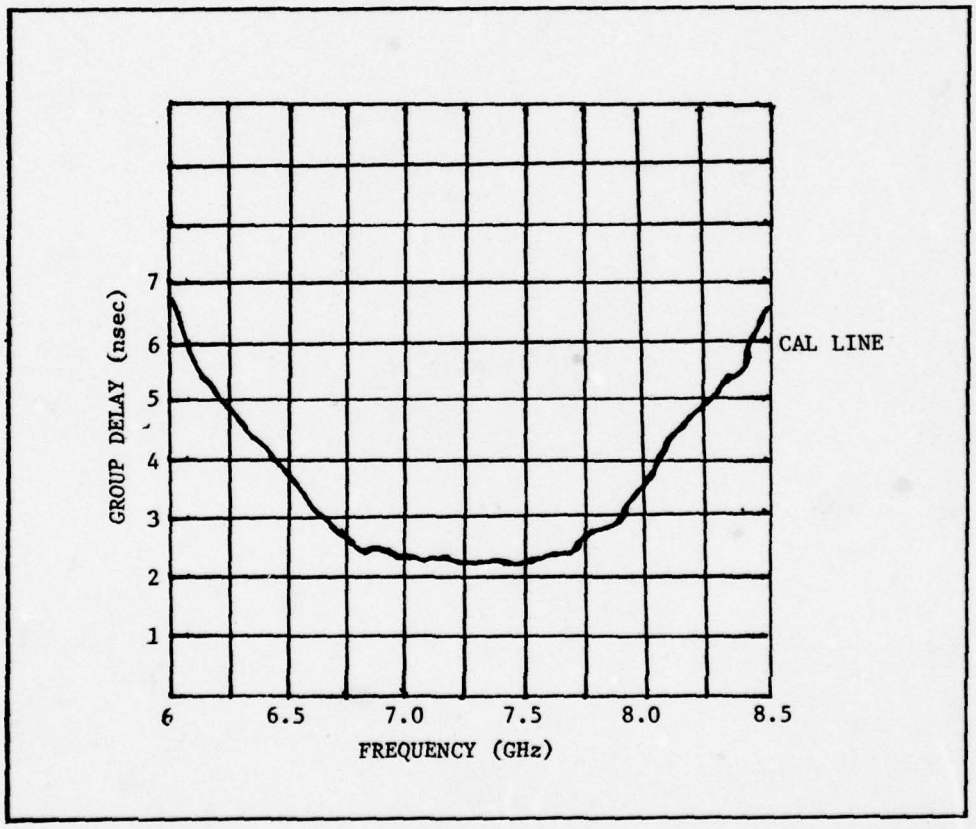


Figure 9-2. Typical group delay filter measurement.

CHAPTER 10

RF INTERFACE INPUT/OUTPUT RETURN LOSS (DT-207)

10-1. GENERAL.

a. The purpose of this test is to measure the return loss at the input and output RF interface points of the radio equipment. The RF interface point is defined as the point at which external waveguide or transmission lines are to be connected to the radio.

b. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

10-2. SPECIFICATIONS.

a. The return loss shall not be less than 26 dB at any frequency within 10 MHz of the assigned transmit and receive carrier frequencies. The radio terminal shall provide specified performance when the antenna feedline presents any return loss greater than 14 dB. (MIL-STD-188-322)

b. The VSWR (AN/FRC-162) looking into the RF interface point from the antenna feedline shall not be more than 1.05:1 (32-dB return loss) over a 15-MHz band, centered on the transmit and receive carrier frequencies. The radio set shall provide specified performance when the feedline VSWR measured at the RF interface point is up to 1.2:1 (20.8-dB return loss) at any phase angle. With a feedline VSWR of 1.2:1, the BER shall not exceed $1x10^{-7}$ at an RSL of -71 dBm. (SCCC-73017)

c. The VSWR (AN/FRC-( )) shall not be more than 1.3:1 over a 20-MHz band, centered on the transmit and receive carrier frequencies. The radio shall provide specified performance when the antenna feedline presents a VSWR of 1.5:1 at any phase angle. (CCC-74049)

NOTE: Although the terminology in subparagraphs b and c above (VSWR) is referred to as return loss in the document cited, the criteria applies.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

10-3. TEST EQUIPMENT REQUIRED.

a. RF sweep generator.

b. Voltage standing wave ratio (SWR) bridge.

c. Directional coupler.

d. Crystal detector.

e. Precision waveguide attenuator.

f. Attenuators, as required.

g. Frequency counter.

h. Coaxial to waveguide adapters.

i. Power meter with thermistor mount.

j. RF termination.

k. Slide screw tuner.

l. X-Y recorder.

m. BER test set.

n. True RMS voltmeter.

o. Digital recorder.

p. Oscilloscope.

10-4. TEST PROCEDURES.

a. Turn off the radio set and connect the test equipment as shown in figure 10-1. Allow approximately 30 minutes for warmup and stabilization.

b. Connect the frequency counter to the output of the RF sweep generator as shown and adjust the sweep limits (F1 and F2) to cover the frequency range of the RF interface point. If a 14-MHz bandwidth is specified, the sweep signal should be set to cover approximately 7.5 MHz each side of the center frequency.

c. Connect a short to directional coupler 2 as shown in figure 10-1.

d. Set the RF sweep generator output to 0 dBm as read on the power meter. The precision attenuator in the reflected power path should be set for zero loss.

e. Temporarily connect the power meter to the reflected power directional coupler. The meter should read -10 dBm or 100-percent reflected power less any loss in the directional coupler.

f. Remove the power meter and reconnect the SWR bridge.

g. Manually sweep the desired bandwidth while observing the generator output on the power meter to ensure that the level remains constant over the required bandwidth. If it does not, manually change the generator frequency at discrete points within the bandpass and manually plot the results on figure 3-4 (DD Form 2094).

h. Adjust the precision attenuator for 35 dB, then return the attenuator to zero loss. This completes the calibration process.

i. Remove the short from the directional coupler and connect the coupler to the RF interface point.

NOTE: If the coupler does not connect directly to the RF interface point, then the termination and calibration should include any connecting waveguide or cable.

j. Sweep the RF interface points and record the results on figure 3-4 (DD Form 2094).

k. Connect the test equipment as shown in figure 10-2, and initially adjust the precision attenuator to provide 50 dB of attenuation.

l. With the transmitter functioning as the signal source, adjust the slide screw tuner for minimum VSWR. Reduce receiver 2 to the specified RSL. For the three-level, partial-response radio, this would be -71 dBm for a BER of $1x10^{-7}$ or better. For the fully digitized radio, it will depend on the bit rate at which the radio was installed. As an example, the RSL at 12.928 mb/s for a BER of $5x10^{-9}$ would be -82.88 dBm for performance level I while performance level II would be -69.88 dBm. The performance at various bit rates based on future radios to be introduced into the inventory are shown in table 10-1.

m. Adjust the slide screw tuner to obtain the VSWR as specified in paragraph 10-2 or as directed in the test plan.

n. Set the pattern generator to the specified bit rate and count the errors for a 1-hour period. Record the number of bit errors and the error rate on figure 3-7 (DD Form 2091).

10-5. DATA RECORDING AND ANALYSIS.

a. Ensure that all information is recorded on figure 3-4 (DD Form 2094) and summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the device fails to meet specifications, notify the responsible activity of required corrective actions.

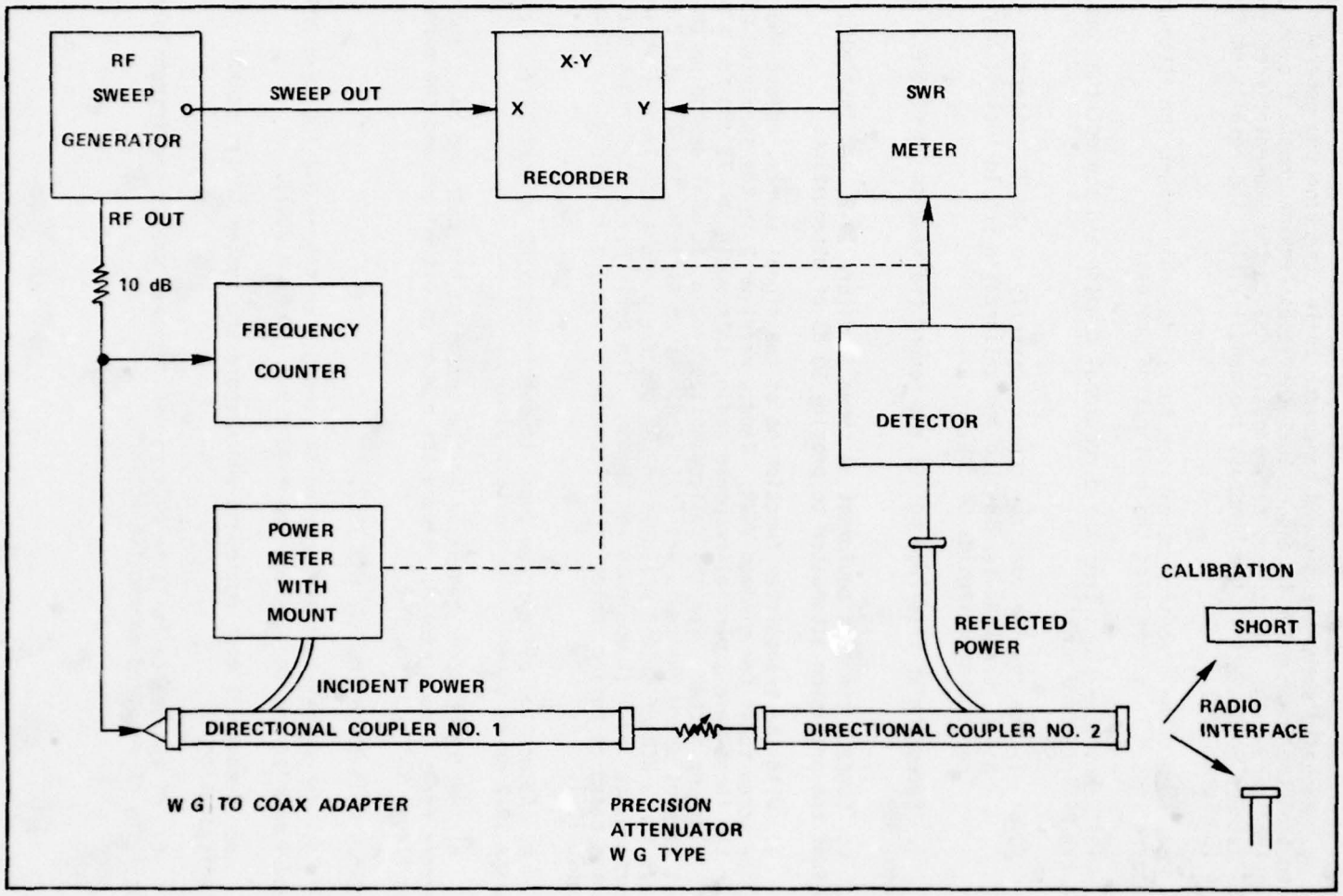


Figure 10-1. RF interface input/output return loss test setup.

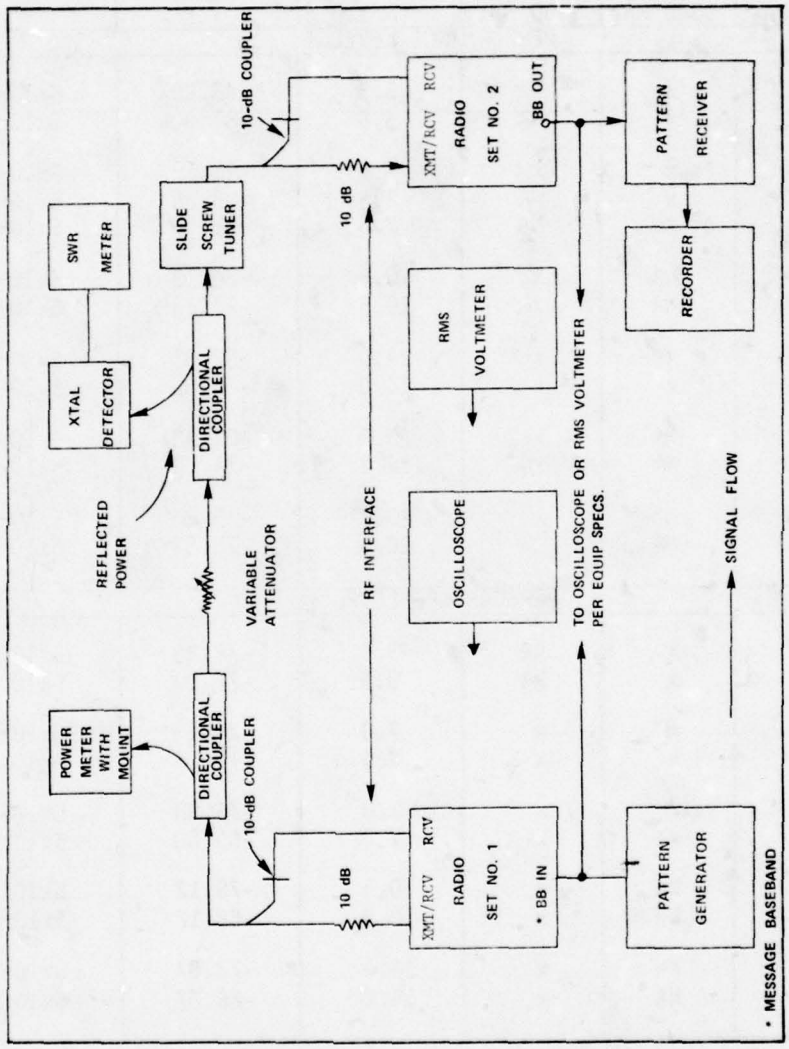


Figure 10-2. RF interface BER test setup.

Table 10-1. RF Interface BER Performance Levels

MBS (mb/s)	BAND 1 4400 to 5000 MHz	BAND 2 7125 to 8400 MHz	BAND-WIDTH (MHz)	RSL (dBm)	BER
PERFORMANCE LEVEL I					
3.232	x	NA	3.5	-88.90	$5x10^{-2}$
3.232	x	NA	3.5	-81.90	$5x10^{-9}$
6.464	x	x	7.0	-85.89	$5x10^{-2}$
6.464	x	NA	3.5	-85.89	$5x10^{-2}$
6.464	x	NA	3.5	-78.89	$5x10^{-9}$
9.696	NA	x	10.5	-84.13	$5x10^{-2}$
9.696	NA	x	10.5	-77.13	$5x10^{-9}$
12.928	x	x	14.0	-82.88	$5x10^{-2}$
12.928	x	x	14.0	-75.88	$5x10^{-9}$
19.392	NA	x	20.0	-81.12	$5x10^{-2}$
19.392	NA	x	20.0	-74.12	$5x10^{-9}$
25.856	NA	x	20.0	-79.87	$5x10^{-2}$
25.856	NA	x	20.0	-72.87	$5x10^{-9}$
PERFORMANCE LEVEL II					
6.464	x	NA	3.5	-79.89	$5x10^{-2}$
6.464	x	NA	3.5	-72.89	$5x10^{-9}$
9.696	x	x	7.0	-78.13	$5x10^{-2}$
9.696	x	x	7.0	-71.13	$5x10^{-9}$
12.928	x	x	7.0	-76.88	$5x10^{-2}$
12.928	x	x	7.0	-69.88	$5x10^{-9}$
19.392	NA	x	10.5	-75.12	$5x10^{-2}$
19.392	NA	x	10.5	-68.12	$5x10^{-9}$
25.856	NA	x	14.0	-73.87	$5x10^{-2}$
25.856	NA	x	14.0	-66.87	$5x10^{-9}$

CHAPTER 11

RADIO EQUIPMENT AND LINK BASEBAND LEVEL VS FREQUENCY (DT-208)

11-1. GENERAL.

a. The purpose of this test is to determine the baseband signal level versus the frequency response, from the baseband signal input of the frequency modulator to the receiver baseband signal output, at the point of input to the receive multiplex.

b. On the AN/FRC-162, this test requires that the FM subcarrier (service channel), pilot oscillator, and the transmit 8.5-MHz roofing filter be removed to measure the message and video baseband limits.

c. This test may be performed on a link or instation loopback basis on the AN/FRC-162.

d. This test is not applicable to the fully digitized radios that are being developed under CCC-74049.

e. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

11-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) The video baseband shall be flat within ±1.5 dB between 300 Hz and 10 MHz.

(2) The message baseband response shall be flat within ±1.5 dB between 300 Hz and 6.4 MHz with the FM subcarrier (service channel), pilot oscillator, 8.5-MHz roofing filter, and 8.1-MHz orderwire equipment installed and operating.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

11-3. TEST EQUIPMENT REQUIRED.

a. Audio frequency (AF)/RF oscillator.

b. Frequency selective voltmeter.

c. Spectrum display unit.

d. True RMS voltmeter.

e. Attenuators.

f. Turnaround mixer.

g. Frequency counter.

11-4. TEST PROCEDURES.

a. Video Baseband Response (Back-to-Back).

(1) Connect the test equipment as shown in figure 11-1 and allow approximately 30 minutes for warmup and stabilization. Refer to figures 11-2 and 11-3 for typical signal flows.

(2) Remove the roofing filters, FM subcarrier (service channel), and pilot tone filters.

(3) At the transmit end, calibrate the oscillator output by connecting the output to the true RMS voltmeter terminated into a 75-ohm impedance. Sweep the oscillator from 300 Hz to at least 10 MHz and observe that the level does not vary more than ±0.5 dB over the frequency range.

(4) Set the oscillator to a 1-MHz baseband frequency and adjust its output for +2.2 dBm. Connect the output to the transmitter input as shown in figure 11-1.

(5) At the receive end, connect the frequency selective voltmeter and RMS voltmeter to the receive baseband output. Place the frequency selective voltmeter in the 75-ohm terminate position and bridge the true RMS voltmeter across the frequency selective voltmeter input.

(6) Observe the 1-MHz test tone on the frequency selective voltmeter at +2.2 dBm ±0.05 dB. If a difference of ±0.5 dB exists between the level measured on the frequency selective voltmeter and RMS voltmeter, spurious intermodulation products or signal tones may be present, influencing the RMS voltmeter reading. If this is the case, examine the baseband spectrum using the frequency selective voltmeter and display unit to determine the cause of the level difference. Any level difference must be corrected before proceeding with the response test.

(7) If the two meter readings are not within ±0.5 dB of +2.2 dBm, perform additional measurements on the transmitter and receiver before proceeding with the frequency response test. To accomplish this, verify the levels at intermediate test points within the transmitter and receiver and adjust the receive baseband output for +2.2 dBm ±0.5 dB.

NOTE: Ensure that the oscillator is set for 75 ohms unbalanced when connected to the transmitter baseband input.

(8) Set the oscillator to 300 Hz and at the receive end, record the level on figure 11-4 (USACC Form 630-R). Adjust the frequency of the oscillator

upward at the frequencies shown on the data sheet, while recording the frequency and level at the receive end. If the output of the transmit oscillator is not flat as determined in paragraph 11-4a(3), establish the correct input level to the transmitter before recording the receive baseband level.

b. Message Baseband Response (Back-to-Back).

(1) Reinsert the roofing filters, FM subcarrier (service channel), and pilot tone fiters.

(2) Connect the equipment as shown in figure 11-1 and repeat paragraphs 11-4a (3) through (8) over a frequency range of 300 Hz to 8.6 MHz. A sharp cutoff should be observed at the high frequency end from the influence of the band suppression filter.

c. Link Baseband Response Versus Frequency.

(1) Connect the equipment as shown in figure 11-1 and repeat paragraphs 11-4a(3) through 11-4b(2).

(2) Mark each data sheet to identify the specific test sequence performed.

11-5. DATA RECORDING AND ANALYSIS.

a. Record all data on figure 11-4 (USACC Form 630-R), plot the results on figure 3-4 (DD Form 2094), and summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the device is not within specified requirements, notify the responsible activity of required corrective actions.

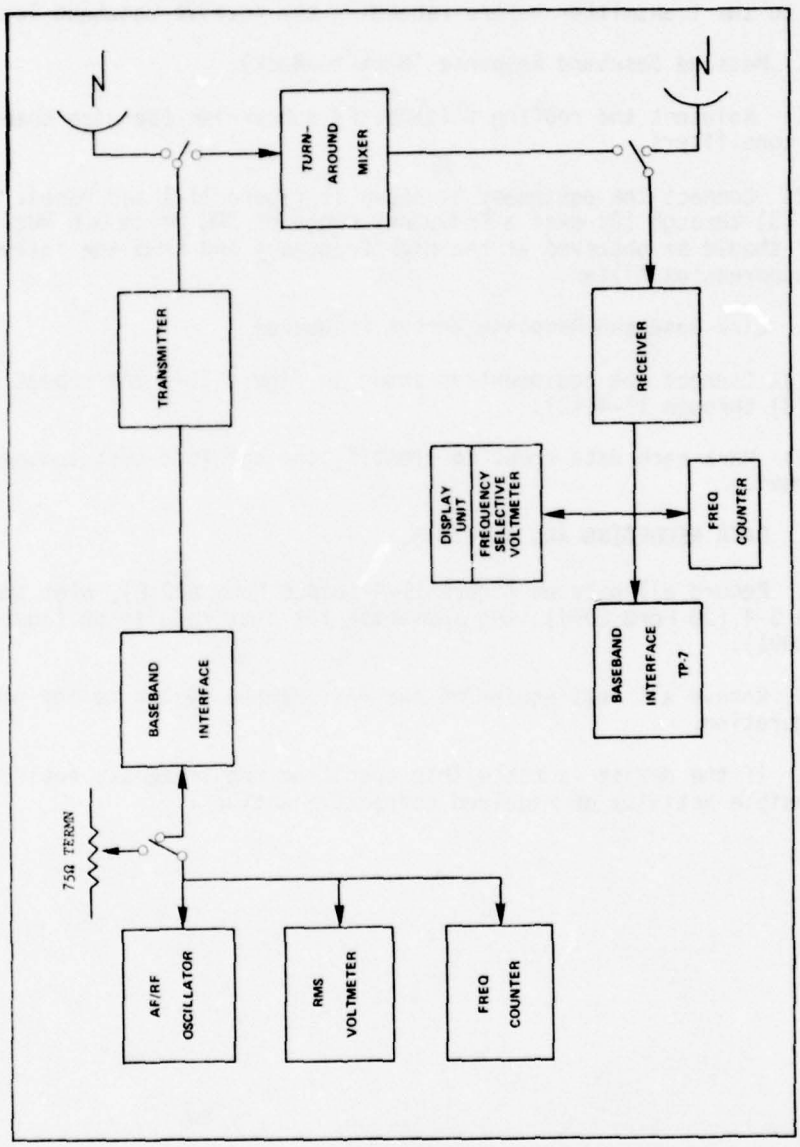


Figure 11-1. Radio equipment and link baseband level vs frequency.

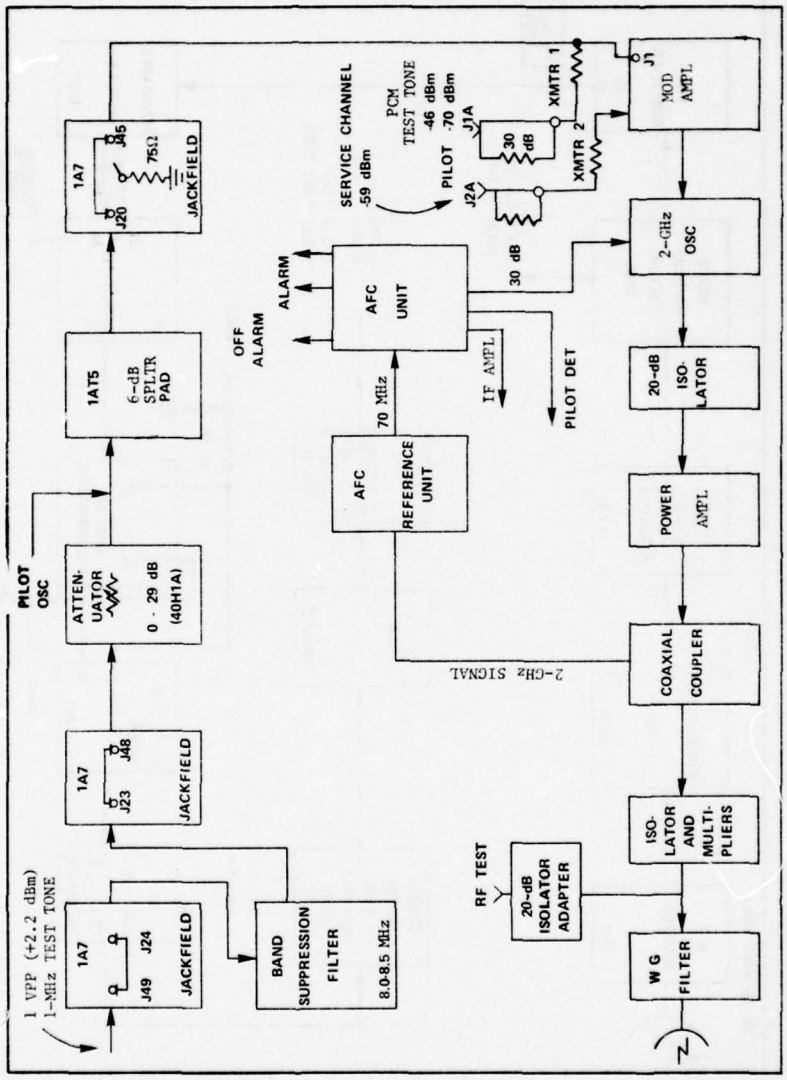


Figure 11-2. Typical signal flow (service channel) (AN/FRC-162 radio).

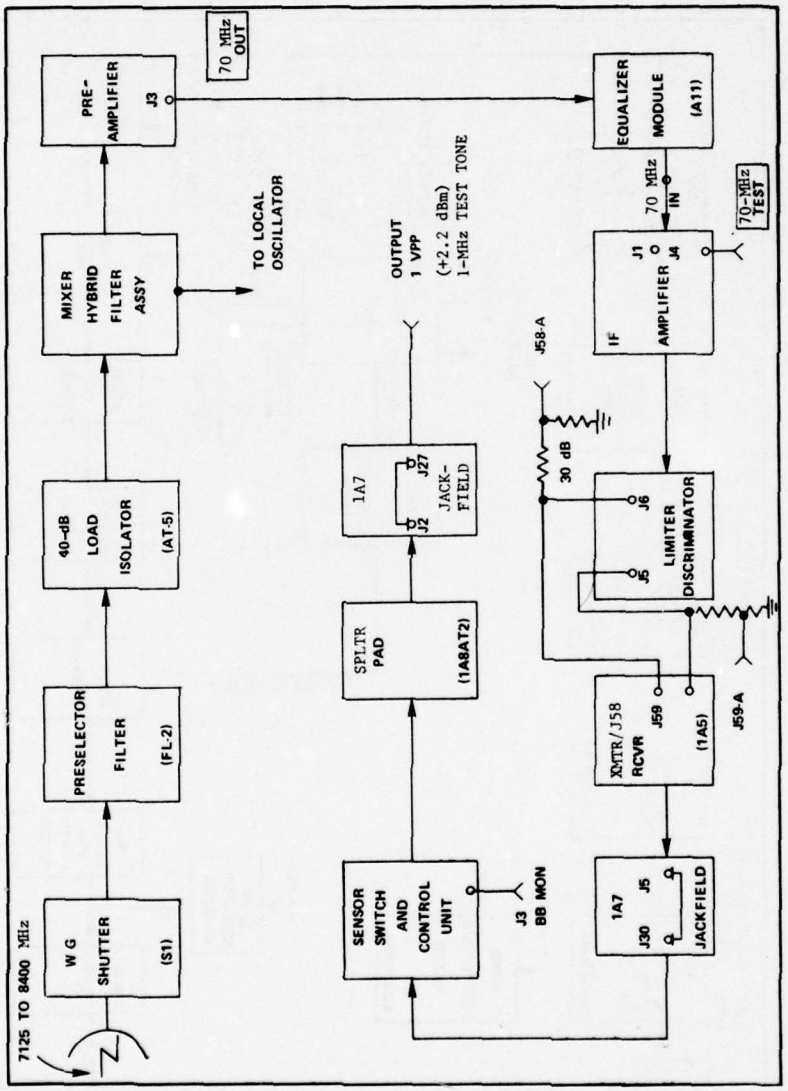


Figure 11-3. Typical signal flow (AN/FRC-162 radio baseband).

MESSAGE BASEBAND INTERFACE (CCR 702-1-3)		PAGE OF PAGES
		DATE (DAY, MO, YEAR)
DATA SHEET		
DISTANT STATION	LOCAL STATION	TEST ENGINEER
TRANSMITTER NO. _____ RECEIVER NO. _____	DESIGN IMPEDANCE (ohms) TRANSMITTER _____ RECEIVER _____	BAL ☐ UNBAL ☐ LINK NO.
CONFIGURATION LINK ☐ LOOP ☐	REF LEVEL _____ dBm _____ VPP	UNIT TESTED TRANSMITTER ☐ RECEIVER ☐

MEASUREMENTS

FREQ Hz	MEAS LEVEL dBm	DIFF dB	FREQ kHz	MEAS LEVEL dBm	DIFF dB	FREQ MHz	MEAS LEVEL dBm	DIFF dB	FREQ MHz	MEAS LEVEL dBm	DIFF dB
300			2.0			1.0			6.5		
400			5.0			2.0			7.0		
500			10.0			2.5			7.5		
600			20.0			3.2			8.0		
700			80.0			4.0			8.5		
800			100.0			4.5			9.0		
900			500.0			5.5			10.0		
1000			900.0			6.0			12.0		

COMMENTS

USACC FORM 630-R
1 MAY 79

Figure 11-4. Message baseband interface data sheet.

CHAPTER 12

RADIO EQUIPMENT BASEBAND ENVELOPE DELAY (DT-209)

12-1. GENERAL.

a. The purpose of this test is to measure the envelope delay of the radio set in a back-to-back configuration.

b. This test is primarily applicable to the AN/FRC-162.

c. The test equipment to be used for this test may differ from that specified, based on local availability.

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to the contract specifications or other applicable documents. It may also be used by quality assurance or installer personnel during onsite test and acceptance as directed.

12-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) With all pilot, supervisory, and roofing filters removed, the measured delay shall be 40 nsec or less over the frequency range of 200 kHz to 10 MHz.

(2) With supervisory filters, pilot tone equipment, and the band suppression filters in place, the measured delay shall not exceed 40 nsec over the frequency range of 200 kHz to 6.4 MHz.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

12-3. TEST EQUIPMENT REQUIRED.

a. Primary.

(1) Analyzer HP 3040A.

(2) Variable attenuator.

(3) Turnaround mixer.

(4) Frequency selective voltmeter.

(5) Frequency counter.

b. Alternate.

(1) Signal Generator TS-PS-42, Wandel and Goltermann.

(2) Generator Attachment LDS-1, Wandel and Goltermann.

(3) Receiver Unit LDE-1, Wandel and Goltermann.

(4) Display Unit GS-1, Wandel and Goltermann.

(5) Oscilloscope TEK-475, Tektronix.

12-4. TEST PROCEDURES.

a. Primary Method.

(1) Perform internal calibration of the test equipment as specified in the technical manual or manufacturer's literature.

(2) For message baseband envelope delay, proceed as follows:

(a) Adjust the levels at the baseband (DT-208) before performing this test.

(b) Remove the pilot oscillator and replace the roofing filter with a looping plug or insert the test signal into J48.

(c) Remove the FM subcarrier (service channel).

(d) Connect the test equipment as shown in figure 12-1 and allow approximately 30 minutes for warmup and stabilization.

(e) Set the sweep output limits of the analyzer from 200 kHz to 10 MHz as measured with the frequency counter.

(f) Adjust the sweep output to correspond to the video input level of +2.2 dBm.

(g) Using the automatic sweep method, at the receiver, record the delay distortion on figure 3-4 (DD Form 2094). In the manual method, record the delay distortion at the frequencies shown on figure 11-4 (USACC Form 630-R).

(h) Restore the pilot oscillator, supervisory channel, and filters that were removed in paragraphs 12-4b (2) and (3).

(3) For message baseband, proceed as follows:

(a) Connect the test equipment as shown in figure 12-1 and set the sweep output of the generator for 200 kHz at +2.2 dBm.

(b) Establish the reference delay on the X-Y terminals of the recorder using 200 kHz to 6.4 MHz.

(c) Turn the sweep on and plot a curve of the delay over the frequency range of 200 kHz to 6.4 MHz.

(4) An alternate procedure to subparagraphs (2) and (3), above, would be to use an automatic network analyzer controlled by a desktop calculator.

b. Alternate Method.

(1) Connect the test equipment as shown in figure 12-1 and allow approximately 30 minutes for warmup and stabilization.

(2) For signal generator adjustments, proceed as follows:

(a) Adjust the generator level using the course level switch and fine level control. The meter reading should be between -1.5 NX and -0.3 NX, preferably -0.5 NS.

(b) Adjust the internal resistance using the R1 switch.

(c) Set the frequency selector switch on the generator attachment to the desired mode of operation.

(d) In positions indicating sweep (entire, partial, or point-to-point), adjust the reference frequency on the scale of the TS-PS-42. The test frequency is then indicated on the scale.

(e) Adjust the reference frequency to the specified range with a lower limit of 200 kHz. The fine detuning oscillator (F6) in the TS-PS-42 detunes the test and reference frequencies by the same amount. Generally, it will be adjusted to 0 kHz.

(f) Set the generator output for automatic sweep at an output level not to exceed 1 VPP (+2.2 dBm).

(3) For delay receiver adjustments, proceed as follows:

(a) Turn the mode switch on the receiver to calibrate. Calibrate the delay and loss separately by adjusting meter 3 to a full-scale reading.

(b) Adjust the reference frequency control for minimum attenuation.

(c) Adjust the test frequency for minimum attenuation. The monitor meter will now indicate the maximum permissible value.

(d) Adjust the monitor meter for full scale when the test and reference frequencies are the same.

NOTE: For the following steps, ensure the delay measuring receiver is in the calibration position.

(e) Operating the X and Y controls of the oscilloscope, adjust the right-hand end point of the lower horizontal line of the calibration pattern to the center of the oscilloscope screen. (This point corresponds to the reference frequency.)

(f) Calibrate the Y-deflection after the receiver monitor meter has been adjusted for full-scale deflection. The screen grid now corresponds to the linear meter scale and full deflection as established on the LDE-1 receiver.

(g) Once calibration of the oscilloscope has been accomplished, if desired, the monitor meter on the LDE-1 receiver can be switched out of the circuit.

12-5. DATA RECORDING AND ANALYSIS.

a. Plot the following curves on figure 3-4 (DD Form 2094) using the procedures in paragraphs 12-4b (1) through (3).

(1) With all pilot and supervisory filters removed, plot a curve of the envelope delay over the 200-kHz to 10-MHz range.

(2) With supervisory filter and pilot tone equipment installed for 12.6-mb/s operation, plot a curve of the envelope delay over the 200-kHz to 6.4-MHz frequency range.

(3) If an X-Y recorder is used to record the data, plot the data on figure 3-4 (DD Form 2094). If photographs of the oscilloscope presentation are taken, mount the photographs on figure 5-2 (DD Form 2093), ensuring accurate calibration notations are provided.

(4) If manual techniques are used, record the raw data at the frequencies shown on figure 11-4 (USACC Form 630-R) and plot the data on figure 3-4 (DD Form 2094).

b. Complete all data sheets, summarize the test results on figure 3-7 (DD Form 2091), and review the data to ensure that it meets specifications.

c. Remove all test equipment and restore the equipment to its normal configuration.

d. If the equipment fails to meet specifications, notify the responsible activity of required corrective actions.

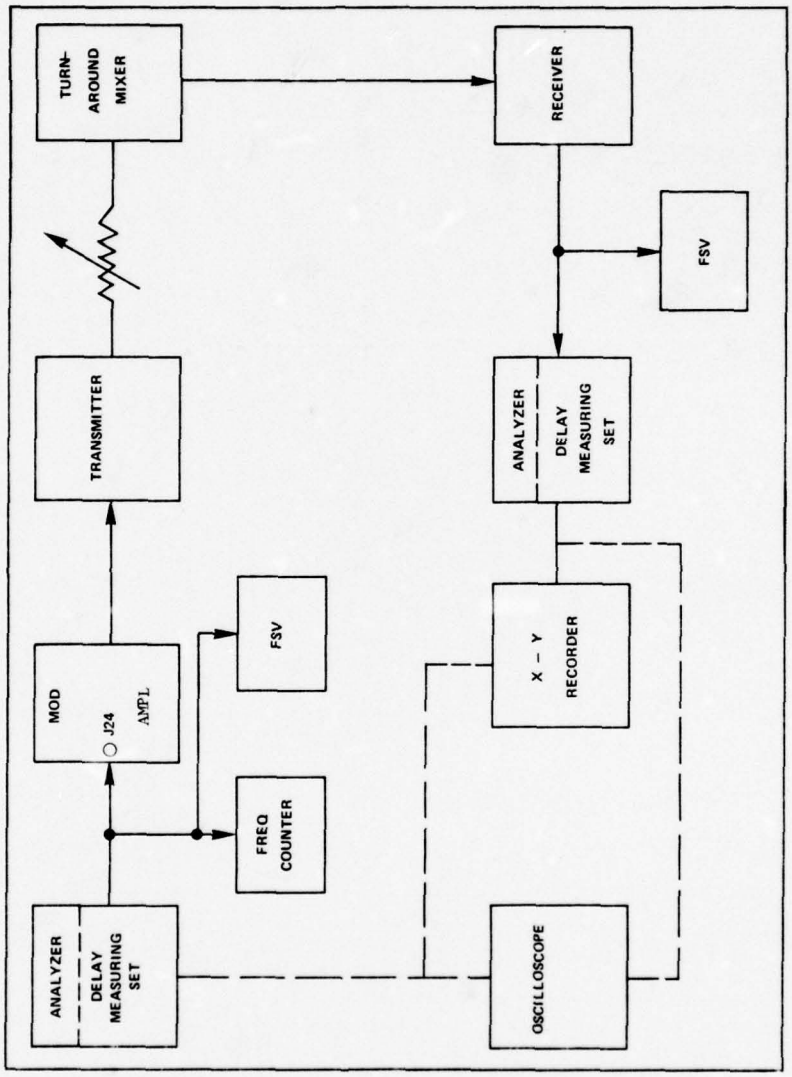


Figure 12-1. Radio equipment baseband envelope delay test setup.

CHAPTER 13

BASEBAND AND RADIO SWITCHING (DT-210)

13-1. GENERAL.

a. The purpose of this test is to:

(1) Measure the bit errors generated when the operating transmitter is switched off and the standby transmitter is switched on.

(2) Measure the bit errors generated when one receiver of a diversity configuration is switched off and the other is switched on.

(3) Measure the baseband switch performance under various configurations.

(4) Measure the bit error performance of the RF switch.

b. This test applies to the AN/FRC-162 radio as well as the AN/FRC-( ) fully digitized system. It does not apply to the hot standby configuration. Certain portions of the procedure may not be applicable to the fully digitized radio without some modification when these radios are introduced into the DCS.

c. The receiver quieting test (DT-224) should be performed before this test so that a current AGC versus RSL graph is available.

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

e. This test may also be performed on a link basis; however, the specifications contained in the procedure are based on a back-to-back configuration with the radio looped at the RF interface point. For over-the-link performance, refer to appendix B.

13-2. SPECIFICATIONS.

a. The following criteria applies to baseband and radio switching. (MIL-STD-188-322)

(1) Any transfer of a transmitter or receiver shall not cause a loss of bit count integrity (BCI), and as a design objective, a manual or remotely introduced transfer shall not cause any errors in the mission bit stream (MBS) or the service channel bit stream (SCBS).

(2) For radio types II and III, a transmitter control function shall be provided for redundancy operation. Provisions shall be included to automatically transfer operation from the active transmitter to the standby

transmitter. The automatic transfer operation shall be based on the following:

(a) Loss for more than 10 milliseconds (msec) of data or timing transition at transmitter MBS ports.

(b) Loss for more than 10 msec of modulator output.

(c) Transmitter frequency drift exceeding 2 percent of the authorized RF transmission bandwidth.

(d) Transmitter output power reduction by 3 dB or more relative to the specified RF output power.

(e) Loss for more than 10 msec of data or timing transitions at the transmitter SCBS port.

(3) In addition to the automatic transfer feature, provisions shall be made to manually or remotely induce a transfer of operation from the active transmitter to the standby transmitter. The manual or remote transfer shall take precedence over the automatic transfer command. The transfer of transmitters shall not cause a loss of BCI, and as a design objective, manual or remote transfer shall not cause any errors in the MBS or the SCBS.

(4) For radio types I, II, and III (receiver diversity operations), provisions shall be made to transfer operation to the better receiver. This transfer shall be automated and based upon the following parameters:

(a) Received signal level.

(b) Eye pattern degradation.

(c) Equipment failure.

(5) Provisions shall be made to manually or remotely induce a transfer of operation from the active to the standby receiver as well as the automatic feature. The transfer of receivers shall not cause loss of BCI or errors in the MBS or the SCBS. The transfer of receivers shall not cause loss of BCI with up to 350 nsec of differential time delay in receive signals.

(6) Diversity and hot standby (performance under switching) operational configurations shall provide for synchronization of the signal processing of alternate sources of signals. The switching shall not cause bit errors or loss of BCI with differential absolute delays up to 350 nsec for transmit and receive signals.

b. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) The baseband switch shall have a high signal level limiting circuit that will, in effect, prevent switching from the inservice half to the

out-of-service half until the inservice half has dropped to an AGC voltage corresponding to signal levels below -66 dBm and above PCM error threshold.

(2) With equal signal levels on both receivers, the baseband switch activated on one receiver, and the other receiver RSL slowly fading, switchover shall not occur.

(3) With equal signal levels on both receivers, the baseband switch activated on one receiver, and that same receiver RSL slowly fading, there shall be a switchover at an RSL difference between the two receivers of 5±2.0 dB, and no errors shall occur due to switchover. The switchover shall not cause the multiplex to lose synchronization or to reframe.

(4) With equal signal levels on both receivers, the baseband switch activated on one receiver, and the other receiver input signal increasing, there shall be a switchover at an RSL difference between the two receivers of 5±2.0 dB and no errors shall occur due to switchover. The switchover shall not cause the multiplexer to lose synchronization or to reframe.

(5) With equal signal levels on both receivers, manually switching the baseband switch from one receiver to the other shall not cause errors. The switchover shall not cause the multiplexer to lose synchronization or to reframe.

(6) With a nominal 6-dB RSL difference in the receivers and the baseband switch on the receiver with the higher input, a permanent fault on that same receiver shall cause switchover to the other receiver and fewer than 50,000 errors shall occur.

(7) With one receiver on-line and the other receiver in standby status, the switch shall switch to the standby receiver upon phase-lock alarm indication, and no errors shall occur. The switchover shall not cause the multiplexer to lose synchronization or to reframe.

(8) The switch shall operate under the above conditions with a delay offset between the two receiver basebands of one-quarter of a bit interval.

c. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) It shall be possible to manually and remotely activate the switchover of transmit or receive functions without causing a loss of BCI in the MBS and the SCBS. Either half of a frequency or space diversity terminal shall be capable of meeting all performance parameters, independent of the other half.

(2) Any of the following transmitter alarms shall be considered a transmitter failure and shall cause the standby transmitter to be switched on-line and the on-line transmitter to be placed in a standby status.

(a) Loss of data activity at either MBS input.

(b) Loss of timing signal at either MBS input.

(c) Loss of modulator output.

(d) Transmitter frequency drift of more than 2 percent of the authorized bandwidth.

(e) Transmitter power output reduced by 3 dB or more.

(f) Loss of data or timing activity at the SCBS. The transmitter switchover shall be inhibited if the standby transmitter exhibits any of the above fault conditions. The only exception shall be subparagraphs (b) through (f), above, on the on-line transmitter with the existence of subparagraph (a) on the standby transmitter. In this case, transmitter switchover shall occur.

(3) To achieve switching between normal and standby transmitters and/or normal and standby receivers without loss of BCI, the radio terminal shall contain a means to equalize differential absolute delay up to 350 nsec for transmit and receive signals.

(4) The total time from the detection of a failure condition to the completion of the switchover shall not exceed 10 microseconds (μsec). No loss of BCI shall occur at the far-end receiver due to the switching action or to the differences in the insertion delay of the on-line or standby transmitter.

(5) The following actions shall occur within 10 μsec after detection of a failure condition.

(a) Failed transmitter will automatically go to standby status and the output will be removed from the RF interface.

(b) The standby transmitter output will switch to RF interface.

(6) The total time from the detection of a failure condition to the completion of the switchover shall not exceed 10 μsec. No loss of BCI shall occur at the far-end receiver due to the switching action or to the differences in the insertion delay of the on-line or standby transmitter.

(7) Any of the following receiver functions shall be considered a receiver failure and shall cause the failed receiver to be switched off-line.

(a) Loss of receive TDM frame synchronization.

(b) Received BER greater than $1x10^{-4}$.

(c) Receiver automatic frequency control (AFC) alarm (if used).

(d) Loss of data or timing signals for 10 μsec or more at any receiver MBS or SCBS output.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

13-3. TEST EQUIPMENT REQUIRED.

a. Digital multiplex.

b. BER test set.

c. Frequency counter.

d. Voltmeter.

e. RF/AF oscillator.

f. Waveguide attenuator.

g. Turnaround mixer.

h. Oscilloscope.

13-4. TEST PROCEDURES.

a. To test the AN/FRC-162 using multiplex equipment, proceed as follows:

(1) Connect the equipment as shown in figure 13-1 and allow approximately 30 minutes for warmup and stabilization. All pilot and supervisory equipment will be included and active. For over-the-link testing, remove the turnaround mixer, attenuators, and 3-dB coupler; and connect the transmitters and receivers to the antenna system.

(2) Verify that the multiplex three-level, partial-response output is 1 VPP and that the transmitter peak deviation is 3.14 MHz. Record this information on figure 13-2 (USACC Form 631-R).

(3) Measure the input to the demultiplexer and also measure and record the pilot deviation and the supervisory channel subcarrier deviation. Input to the demultiplexer should be 1 VPP, pilot deviation should be 140 kHz RMS, and the supervisory channel subcarrier should be 700-kHz peak deviation. Record the results.

NOTE: The PCM signal polarity is reversed through the microwave link when combiners are not used; therefore, it may be necessary to reverse the wires to the PCM equipment.

(4) Apply a -10 dBm0, 4-kHz test tone to the supervisory channel input and terminate the receive output of the supervisory channel.

(5) Connect the frequency counter to the error test point on the test word generator.

NOTE: Maintain a short test lead length between the error test point and the frequency counter to preclude introducing unnecessary errors.

(6) Adjust the input sensitivity of the frequency counter by depressing the error injection switch on the test word generator and adjusting the error count on the frequency counter to 47 errors per second. These adjustments may be made with the multiplex connected back-to-back or through the radio set with a -30 dBm RSL.

(7) Turn the function switch on the frequency counter to manual start to measure total errors during baseband switchover.

(8) Adjust the turnaround mixer to the center frequency of the receivers and adjust attenuator 1 to provide a safe operating level for the mixer. Set attenuators 2 and 3 (fig. 13-1) to provide an equal signal level of -30 dBm to receivers A and B as measured with the voltmeter. The calibrated curve of AGC versus RSL developed during the receiver quieting test (DT-224) can be used to set the RSL. Ensure that the baseband switch is set on receiver A.

(9) Slowly reduce the signal level to that of receiver A. Switchover to receiver B should occur at an RSL of -66 dBm ±3 dB. Record the RSL at which switchover occurs on the data sheet. Repeat subparagraphs (2) through (9), above, for equal signal levels of -40, -50, and -60 dBm.

(10) Repeat subparagraphs (2) through (9), above, for receiver B.

(11) Set the RSL's on receivers A and B to -70 dBm. Ensure that the baseband switch is set on receiver A. Slowly reduce the signal level on receiver B from -70 to -80 dBm and verify that the baseband switch remains on receiver A.

(12) Reverse the roles of receivers A and B and repeat paragraph 13-4a(11).

(13) Adjust the RSL on both receivers to -64 dBm with the baseband switch set on receiver A. Slowly reduce the RSL to that of receiver A until switchover occurs. Record the receiver A RSL and the number of errors on the frequency counter.

(14) Reverse the roles of receivers A and B and repeat paragraph 13-4a(13). Record the results.

(15) Set the RSL's on receivers A and B to -70 and -76 dBm, respectively. Ensure that the baseband switch is set on receiver A, that the frequency counter is reset to zero, and that the function select switch is set to manual start. Slowly increase the receiver B signal level until switchover occurs. Record the receiver B RSL and the number of errors read on the frequency counter. Repeat this paragraph 10 times to obtain an average error count.

(16) Reverse the roles of receivers A and B and repeat paragraph 13-4a(15). Record the results.

(17) Set the RSL on both receivers to -70 dBm and manually switch between receivers A and B noting any errors between switch changes. Record the number of errors.

(18) Set the RSL on receivers A and B to -64 and -70 dBm, respectively. Ensure that the baseband switch is set on receiver A. Simulate a fault in receiver A and verify that the baseband switched to receiver B. Record the number of errors. Reset the counter to zero and remove the simulated fault on receiver A. Verify that switchover occurs and record the number of errors on figure 13-2 (USACC Form 631-R). Repeat this paragraph 10 times to obtain an average error count.

(19) Reverse the roles of receivers A and B and repeat paragraphs 13-4a (17) and (18).

(20) Record any loss of synchronization or reframes resulting from paragraphs 13-4a (1) through (19).

b. To test the AN/FRC-162 without multiplex equipment, proceed as follows:

(1) Connect the equipment as shown in figure 13-3, ensuring that the output of the BER test set is compatible with the radio baseband input.

(2) Set the pattern generator to 12.6 mb/s at an output of 1 VPP.

(3) Insert a -10 dBm0 tone at a frequency of 4 kHz into the transmit end of the supervisory channel. At the receive end, terminate the supervisory output channel into its characteristic impedance.

(4) Adjust attenuator 1 for a safe operating level into the turnaround mixer and adjust the mixer for the center frequency of the receivers as evidenced by the maximum AGC voltage as read on the voltmeter.

(5) Adjust the RSL on receivers A and B to -30 dBm and set the baseband switch on receiver A. Slowly reduce the signal level on receiver A and observe the point at which switchover to receiver B occurs. Switchover should occur at an RSL of -66 dBm ±3 dB. Repeat the procedure for equal signal levels of -40, -50, and -60 dBm.

(6) Reverse the roles of receivers A and B and repeat paragraph 13-4b(5) to verify the receiver B performance. Record the results on figure 13-4 (USACC Form 632-R).

(7) Adjust attenuators 2 and 3 to provide equal signal levels of -66 dBm to both receivers. With the baseband switch set on receiver A, slowly reduce the RSL on receiver A until switchover occurs. Record the difference between the RSL's of receivers A and B at which switchover occurs and the number of errors on the error counter.

(8) Adjust attenuators 2 and 3 to provide equal signal levels of -66 dBm to both receivers with the baseband switch set on receiver B. Slowly reduce the attenuation of receiver B and observe that switchover occurs as the RSL to receiver A increases 5±2.0 dB, from the receiver B level. Record the difference between the RSL's at the point where switchover occurs and the number of errors.

(9) Set the RSL's of receivers A and B to -70 dBm and manually switch between the receivers while observing and noting any errors on the error detector test set. Record the number of errors.

(10) Set the RSL's on receivers A and B to -64 and -70 dBm, respectively. Ensure that the baseband switch is set on receiver A. Simulate a fault in receiver A and verify that baseband switchover to receiver B occurs. Record any errors. Reset the error counter to zero, remove the simulated fault in receiver A, and verify that switchover occurs. Record any errors.

(11) Repeat paragraphs 13-4b (5) through (10) for receiver B to A configuration.

(12) Repeat paragraphs 13-4b (5) through (10) 10 times for the A to B and B to A combinations to obtain an average error count.

c. To test the fully digitized AN/FRC-( ), proceed as follows:

(1) Manual and remote switchover.

(a) Connect the test equipment as shown in figure 13-5. Adjust the output voltage level of the data generator to 1 VPP at the digital input ports. The design specification for the input voltage of the radio is ±0.2 to ±7.0 volts without impairing radio performance. This requirement will be demonstrated in a subsequent procedure.

(b) Manually place transmitter A and receiver A on-line.

(c) Initially adjust attenuator 1 for 30-dB attenuation and tune the turnaround mixer to the center frequency of the receiver.

(d) Adjust attenuator 1 for an RSL of -30 dBm on receiver A with attenuators 2 and 3 providing zero attenuation. Run a test sequence with the pattern generator to ensure there are no errors on the receive bit error detector.

(e) With attenuators 2 and 3, adjust the RSL on receivers A and B to performance level I for a BER of $5x10^{-9}$ as shown in table 10-1. Manually switch to receiver B, and record the errors observed during switching on figure 13-4 (USACC Form 632-R). Manually switch back to receiver A and record any errors.

(f) Reduce the RSL as shown in table 10-1 on both receivers for a BER of $5x10^{-2}$, performance level I. Manually switch to receiver B and record the errors observed during switching. Manually switch back to receiver A and record any errors.

NOTE: It may be necessary to equalize the delay between the data channels before performing the above test.

(g) Repeat subparagraphs (b) through (f), above, for performance level II (if applicable) as shown in table 10-1. Record any errors.

(h) Place receiver B off-line and adjust the RSL on receiver A to that specified for performance level I for a BER of $5x10^{-9}$. Transmit data for 5 minutes. Record any errors. Repeat this procedure for performance level II, if applicable, and record the results. Reduce the RSL as shown in table 10-1 for a BER of $5x10^{-2}$, performance level I, and transmit data for 5 minutes. Record any errors. Adjust the RSL for a BER of $5x10^{-2}$, performance level II, and transmit data for 1 hour. Record any errors.

(i) Place receiver A off-line and receiver B on-line and repeat subparagraph (h), above. Record the results.

(j) With transmitter A on-line and the RSL on both receivers adjusted to performance level I, for a BER of $5x10^{-9}$, switch transmitter A off-line and observe any errors. Manually switch transmitter B off-line; transmitter A should activate. Record any errors.

(k) Repeat subparagraph (j), above, for performance level II, manually and in the remote position, for each combination of receivers.

(2) Transmitter switching resulting from alarms.

(a) Place transmitter A on-line and transmitter B off-line. Adjust the RSL on both receivers for a BER of $5x10^{-9}$ as shown in table 10-1. Momentarily remove the data input (MBS-1) from transmitter A. Transmitter B should come on-line and transmitter A should go to standby. Record the switching as well as any errors observed on figure 13-4 (USACC Form 632-R). The transmitter select switch should be placed in the automatic position for this test. Restore the data input to transmitter A and observe that transmitter A comes on-line and transmitter B returns to standby.

(b) Place transmitter B on-line and transmitter A on standby. Remove one of the MBS inputs from transmitter B and observe that transmitter A comes on-line and transmitter B goes off-line.

(c) Remove or disable the timing signal (MBS-1) from transmitter A and observe that transmitter B comes on-line and transmitter A goes to standby. Remove or disable the timing signal from the MBS-2 input and observe that transmitter A goes to standby and transmitter B comes on-line. Record any errors.

(d) Repeat subparagraph (c), above, with transmitter B functioning as the prime on-line unit and transmitter A as the standby unit. Record the results.

(e) With transmitter A on-line and transmitter B on standby, temporarily remove the modulation from transmitter A. Observe that an alarm activates in 10 msec and transmitter B comes on-line and transmitter A goes to standby.

Repeat the procedure with transmitter B on-line and transmitter A on standby. Record the results.

(f) Place transmitter A on-line and transmitter B on standby. Slowly adjust the frequency of transmitter A and observe that transmitter B comes on-line when the transmitter A frequency exceeds more than 2 percent of the authorized bandwidth as shown in table 10-1.

NOTE: The AFC, if so equipped, must be disabled.

(g) Reverse the roles of transmitters A and B and observe that transmitter A comes on-line when the transmitter B frequency exceeds 2 percent of the authorized bandwidth. Record any errors.

(h) Verify that the power output of transmitters A and B is within the requirements of table 10-1. Record the power output level.

(i) With transmitter A on-line, reduce the output power of the transmitter by 3 dB. An alarm should activate and transmitter B should come on-line within 10 µsec. Reverse the roles of transmitters A and B, and repeat the test. Record the results.

(j) With transmitter A on-line and transmitter B on standby, remove the input data from the service channel of transmitter A. Transmitter A should go to standby and transmitter B should come on-line. Restore the data to the transmitter A service channel, and with transmitter A on-line, remove the service channel timing. Transmitter B should come on-line. Restore the data to the transmitter A service channel, and with transmitter A on-line, remove the service channel timing. Transmitter B should come on-line and transmitter A should go to standby. Reverse the roles of the transmitters and repeat the test for the transmitter B input. Record the results.

(3) Transmitter inhibit switching.

(a) Place transmitter A on-line and transmitter B on standby.

(b) Introduce the following faults (in sequence and one at a time) on the standby transmitter. Observe that transmitter A remains on-line.

1. Loss of timing signal at either MBS input.

2. Loss of modulator output.

3. Transmitter off frequency by more than 2 percent of the authorized bandwidth.

4. Transmitter power output 3 dB below the required output.

5. Loss of data and/or timing at the SCBS.

(c) Remove all faults on the standby transmitter.

(d) On transmitter B (standby), remove the MBS-1 data input from the transmitter. In sequence and one at a time, introduce the above faults on transmitter A, and observe that transmitter B comes on-line and transmitter A goes on standby. An alarm should be observed for each sequence. Record the results.

(e) Reverse the roles of the transmitters and repeat subparagraph (d), above, with transmitter B on-line and transmitter A on standby.

(f) Record the switching time for each occurrence as well as any loss of BCI.

(4) Receiver switchover.

(a) On receiver A, introduce delay into the receiver so that TDM frame synchronization is lost. Receiver A should go to standby and receiver B should go on-line.

(b) Place receiver A back on-line and receiver B on standby. Reduce the RSL on receiver A until a BER of greater than $1x10^{-4}$ is being experienced. Receiver A should go off-line and receiver B should go on-line. Record the results on figure 13-4 (USACC Form 632-R).

(c) Place receiver A back on-line and receiver B on standby. Remove (in sequence and one at a time) MBS timing, MBS data output, SCBS timing, and SCBS data output from receiver A. Observe that switchover occurs within 10 msec.

(5) Receiver BER performance floor.

(a) Reduce the RSL of both receivers by 20 dB above that shown in table 10-1.

(b) Transmit data into MBS-1, MBS-2, and the SCBS at the specified bit rate. The minimum recording should be 1 hour for each performance level and at the design rate of the radio. Sufficient sampling must be performed to determine that the radio meets the confidence factor of one error in 10^{-10} bits 95 percent of the time. Record the results on figure 13-4 (USACC Form 632-R).

13-5. DATA RECORDING AND ANALYSIS.

a. Record all test data on the appropriate data sheets and summarize the results on figure 3-7 (DD Form 2091).

b. Review all test data to ensure that the equipment meets the specified performance level.

c. Remove all test equipment and restore the system to its normal configuration.

d. If a device fails, notify the responsible activity of the required corrective actions.

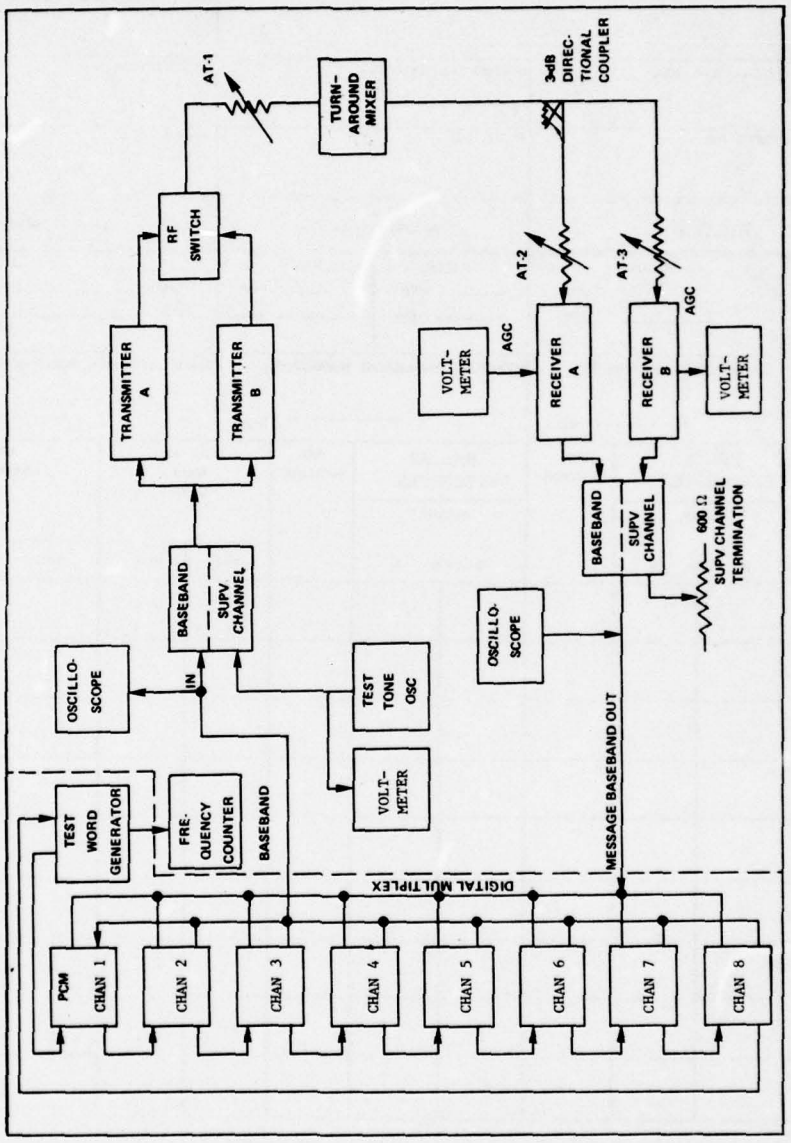


Figure 13-1. Back-to-back switching with multiplex test setup.

SWITCHING PERFORMANCE
(CCR 702-1-3)

PAGE ____ OF ____ PAGES

DATE (DAY, MO., YEAR)

DATA SHEET

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR NO.	XMTR NO.	RCVR NO.	RCVR NO.

SPECIFICATION		MEASURED LEVEL		SUPV ORDERWIRE
XMTR	RCVR	XMTR	RCVR	
_____ VPP _____ dBm	_____ VPP _____ dBm	_____ VPP _____ dBm	_____ VPP _____ dBm	SUPV _____ dBm O/W _____ dBm

PILOT DEVN	SUPV CHANNEL DEVN	MESSAGE BASEBAND IMPEDANCE	SUPV CHANNEL IMPEDANCE
_____ kHz	_____ kHz	_____ ohms	_____ ohms

RCVR RSL dBm	RSL AT SWITCHOVER RCVR A TO B	NO. ERRORS	RSL AT SWITCHOVER RCVR B TO A	NO. ERRORS	LOSS OF MUX SYNC YES	LOSS OF MUX SYNC NO	MUX REFRAMES YES	MUX REFRAMES NO
-30								
-40								
-50								
-60								
-64								
-66*								
-70								
-75								
-80								

*RSL DIFFERENCE AT SWITCHOVER _____ dBm AVERAGE NO. ERRORS _____

SWITCHING TIME μsec _____ nsec _____

A TO B										
B TO A										

USACC FORM 631-R
1 MAY 79

Figure 13-2. Switching performance data sheet.

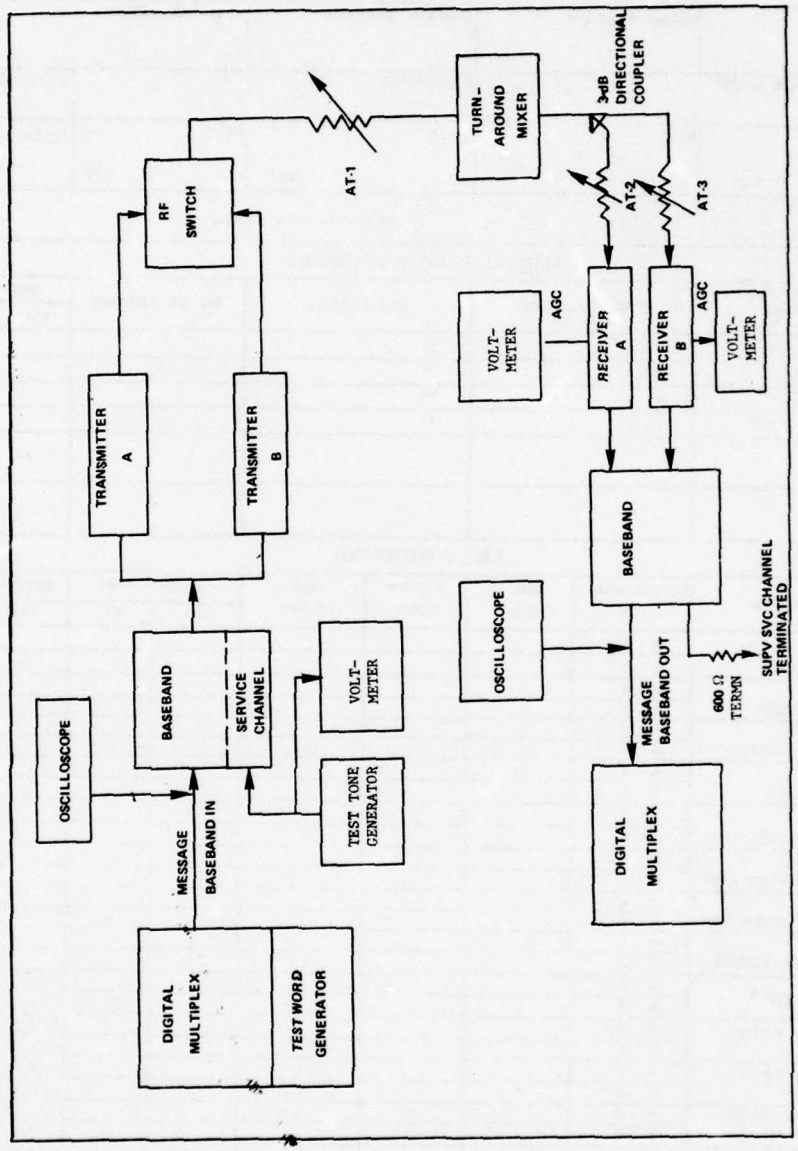


Figure 13-3. Back-to-back switching without multiplex test setup.

CCP 702-11

SWITCHING AND BER PERFORMANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY,MO.,YEAR)	
DCS LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER	
BASEBAND DESIGN LEVEL		MEASURED		SCBS DESIGN
XMTR V PP	RCVR V PP	XMTR V PP	RCVR V PP	SCBS V PP
DATE RATE	mb/s	PERFORMANCE LEVEL		

MANUAL REMOTE SWITCHING

BER LEVEL	CONFIGURATION	RSL (dBm)	NO. OF ERRORS	SWITCH TIME MBS	SWITCH TIME RF
5×10^{-2}	A - B	**			
	B - A	**			
5×10^{-9}	A - B	**			
	B - A	**			

FAULT SWITCHING

TEST CONDITION	CONFIGURATION	RSL (dBm)	ALARM RCVD	NO. ERRORS	SWITCH TIME MBS	SWITCH TIME RF	SWITCH INHIBIT* YES	SWITCH INHIBIT* NO
MBS DATA LOSS*	A - B							
	B - A							
MBS TIMING LOSS*	A - B							
	B - A							
MODULATION LOSS*	A - B							
	B - A							
2% FREQ DRIFT*	A - B							
	B - A							
3-dB POWER LOSS*	A - B							
	B - A							
SCBS INPUT TIMING LOSS*	A - B							
	B - A							
SCBS OUTPUT DATA LOSS*	A - B							
	B - A							
LOSS OF RCV FRAME	A - B							
	B - A							
BER > 1×10^{-4}	A - B							
	B - A							
RECEIVE MBS TIMING LOSS	A - B							
	B - A							
LOSS OF MBS DATA OUTPUT	A - B							
	B - A							
LOSS OF SCBS TIMING (RCV)	A - B							
	B - A							
LOSS OF SCBS (RCV) DATA OUT	A - B							
	B - A							

** BER PERFORMANCE FLOOR RSL 20 dB ABOVE PERFORMANCE LEVEL			TIME RECORDED _____ TOTAL NO. ERRORS _____
	5×10^{-2}		
	5×10^{-9}		

USACC FORM 632-R
1 MAY 79

Figure 13-4. Switching and BER performance data sheet.

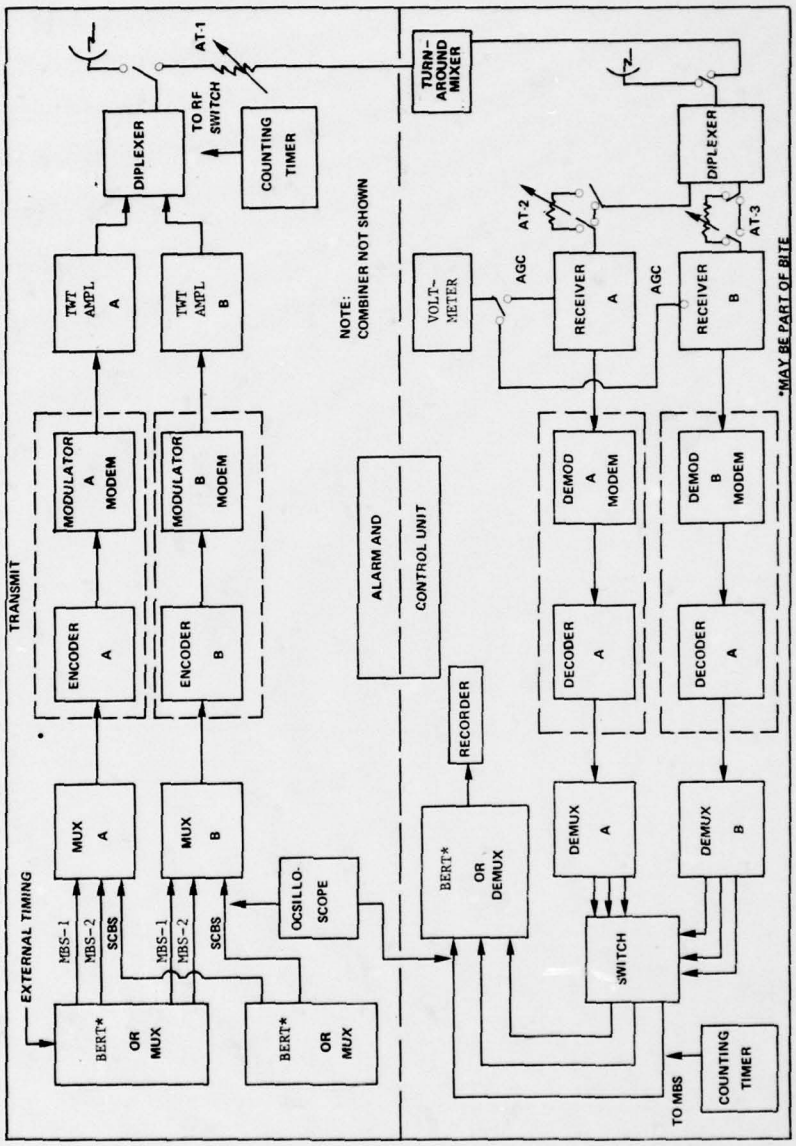


Figure 13-5. Switching error test setup.

CHAPTER 14

MESSAGE BASEBAND INTERFACE (THREE-LEVEL, PARTIAL-RESPONSE RADIO) (DT-211)

14-1. GENERAL.

a. The purpose of this test is to measure the baseband return loss and output level in a back-to-back configuration. This test may also be performed on a link basis; however, the specifications in paragraph 14-2 may not apply.

b. In the three-level, partial-response radio, the return loss over the frequency range of 300 Hz to 6.4 MHz should be greater than 26 dB. The receiver output over the same frequency spectrum should be 1.0±0.25 VPP.

c. Two basic methods are described in the procedure for determining the return loss: direct measurement by use of a return loss bridge and a comparison method.

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

14-2. SPECIFICATIONS. The following criteria applies to message baseband interface on the three-level, partial response radio. (Amendment IV (Revised) to DCSS-1-70(A))

a. The radio set shall deliver specified performance when the test tone signal level at the baseband input is 1.0±0.25 VPP.

b. With a 1.0 VPP input signal to the transmitter, the receiver shall deliver an output tone signal level of 1.0±0.25 VPP.

c. Input and output baseband impedances shall be 75 ohms unbalanced, exhibiting a return loss of 26 dB or greater over the 300-Hz to 6.4-MHz band. These requirements are with service channel equipment, pilot tone equipment, and band suppression filter in place.

14-3. TEST EQUIPMENT REQUIRED.

a. Signal generator.

b. Frequency selective voltmeter.

c. Oscilloscope or RMS voltmeter.

d. Return loss bridge/impedance test set.

e. 75-ohm precision resistors.

f. RF attenuator.

g. Turnaround mixer.

h. Frequency counter.

14-4. TEST PROCEDURES.

a. Return Loss (Bridge).

(1) Connect the test equipment as shown in figure 14-1 (calibration) and allow approximately 30 minutes for warmup and stabilization.

(2) Ensure that the service channel equipment, pilot tone equipment, and band suppression filters are installed.

(3) Connect the 75-ohm coaxial cables to the output of the signal generator and set the output level to 1 VPP (+2.2 dBm). Initially set the generator frequency for 3.2 MHz and verify the generator output level and frequency.

(4) Record the generator output frequency and level on figure 11-4 (USACC Form 630-R).

(5) Set the generator output frequency to 300 Hz and slowly increase the generator frequency over the range of 300 Hz to 7.0 MHz. The generator output over the required spectrum should be flat when terminated into the 75-ohm termination. If variations of more than ±1 dB are noted, it may be necessary to obtain another generator.

(6) Connect the generator output to J1 of the return loss bridge and set the frequency to 3.2 MHz at a level of 1 VPP.

(7) Set the generator output frequency to 300 Hz and increase the generator frequency in increments from 300 Hz to 7.0 MHz. Record the measured level at each frequency and compute the level difference. Any level difference noted in the test cables or return loss bridge must be considered when performing paragraph 14-4(8), below.

NOTE: If the frequency selective voltmeter will not accurately measure to 300 Hz, it may be necessary to substitute a wave analyzer for the low frequency measurements.

(8) Connect the generator output to the transmit baseband input (figure 14-2), at a frequency of 3.2 MHz and at a level of 1 VPP. Adjust the transmit baseband attenuator for -46 dBm at J1-A as measured with the frequency selective voltmeter.

(9) Connect the frequency selective voltmeter to the receive baseband output (J2) and adjust the receive high level adjustment for a 1 VPP reading. Record the levels.

(10) Connect the test equipment as shown in figure 14-2 and tune the frequency selective voltmeter to 1 kHz. With J3 open, obtain a reference level on the frequency selective voltmeter.

NOTE: If the frequency selective voltmeter will measure to 300 Hz, then this frequency should be used instead of 1 kHz. If the frequency selective voltmeter will not accurately measure below 1 kHz, it may be necessary to use a wave analyzer to measure the low frequency end of the baseband.

(11) Connect the message baseband input (J24) to J3 of the return loss bridge as shown in figure 14-2 and record the level as measured on the frequency selective voltmeter. The difference in level obtained is the return loss at the point of measurement. As an example, if the reference level is 50 dB and the measured level is 76 dB, the return loss would then be 26 dB.

b. Return Loss (Comparison).

(1) Connect the test equipment as shown in figure 14-3.

(2) With the generator terminated into a precision 75-ohm resistor, adjust the output level for 1 VPP at a frequency of 3.2 MHz.

(3) Set the generator output frequency to 300 Hz and observe that there is no significant change in level.

(4) Increase the generator output in increments as shown in figure 11-4 (USACC Form 630-R) and record any level differences. If the generator output is flat (±1 dB over the 300-Hz to 7.0-MHz spectrum) proceed to paragraph 14-4b(5), below. If a significant difference exists at one or more frequencies, it may be necessary to change generators.

(5) Connect the generator to the baseband input or output and set the output frequency to 3.2 MHz. Establish a 1-VPP input level as read on the oscilloscope. Record this as the reference frequency and level.

(6) Set the generator output frequency to 300 Hz but do not readjust the output level.

(7) Increase the generator output frequency in increments as shown in figure 11-4 (USACC Form 630-R) and record the level variations for each frequency.

(8) Compute the return loss from:

$$20\log_{10}\left|\frac{Z_2 + Z_1}{Z_2 - Z_1}\right| \text{ dB}$$

(9) Plot the response data on figure 3-4 (DD Form 2094), with the frequency on one axis and return loss on the other axis of the graph.

(10) Refer to figure 14-4 for impedance conversion information.

14-5. DATA RECORDING AND ANALYSIS.

a. Record all data on the data sheets, summarize the test results on figure 3-7 (DD Form 2091), and review the test results to ensure the measured data conforms to specifications.

b. Remove all test equipment and restore the system to its normal configuration.

c. If the test results are not within specifications, notify the responsible activity of required corrective actions.

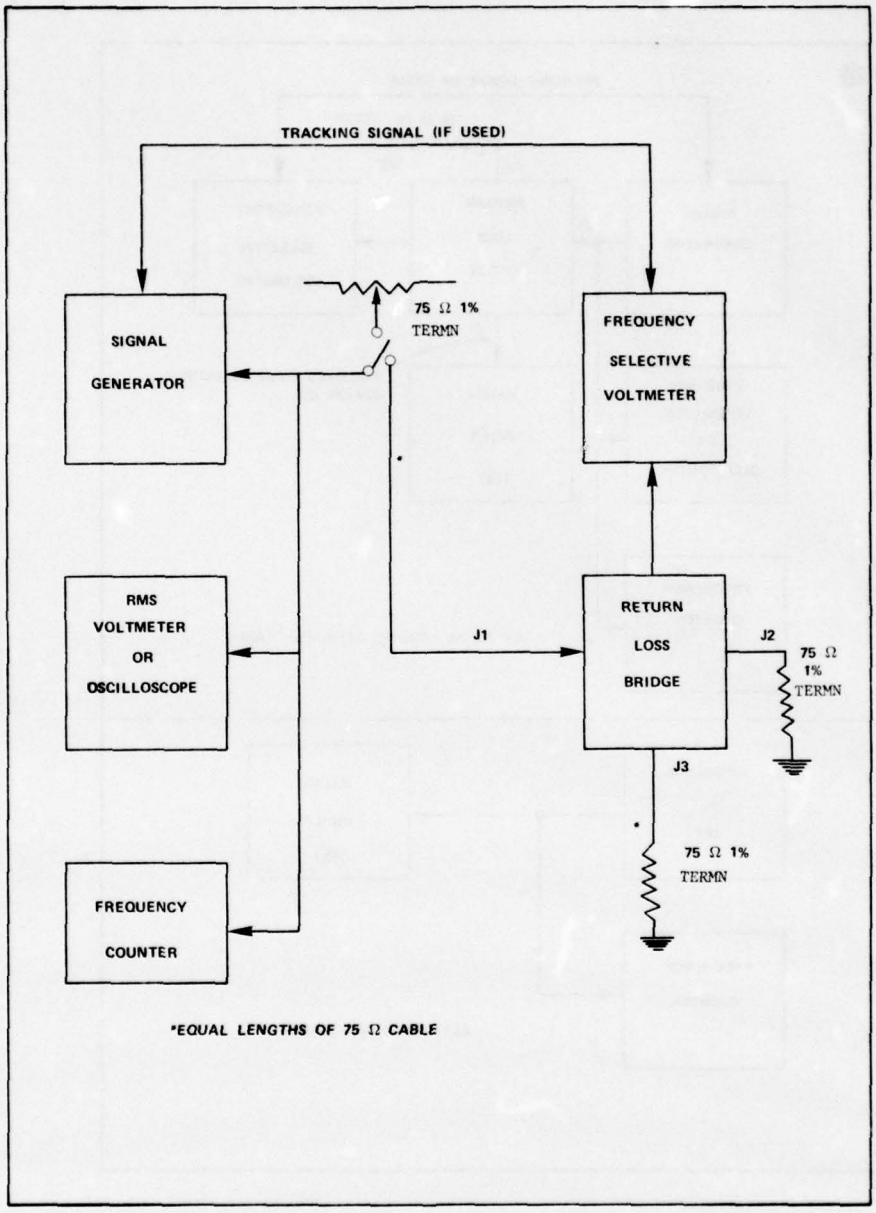


Figure 14-1. Baseband interface (bridge) (calibration).

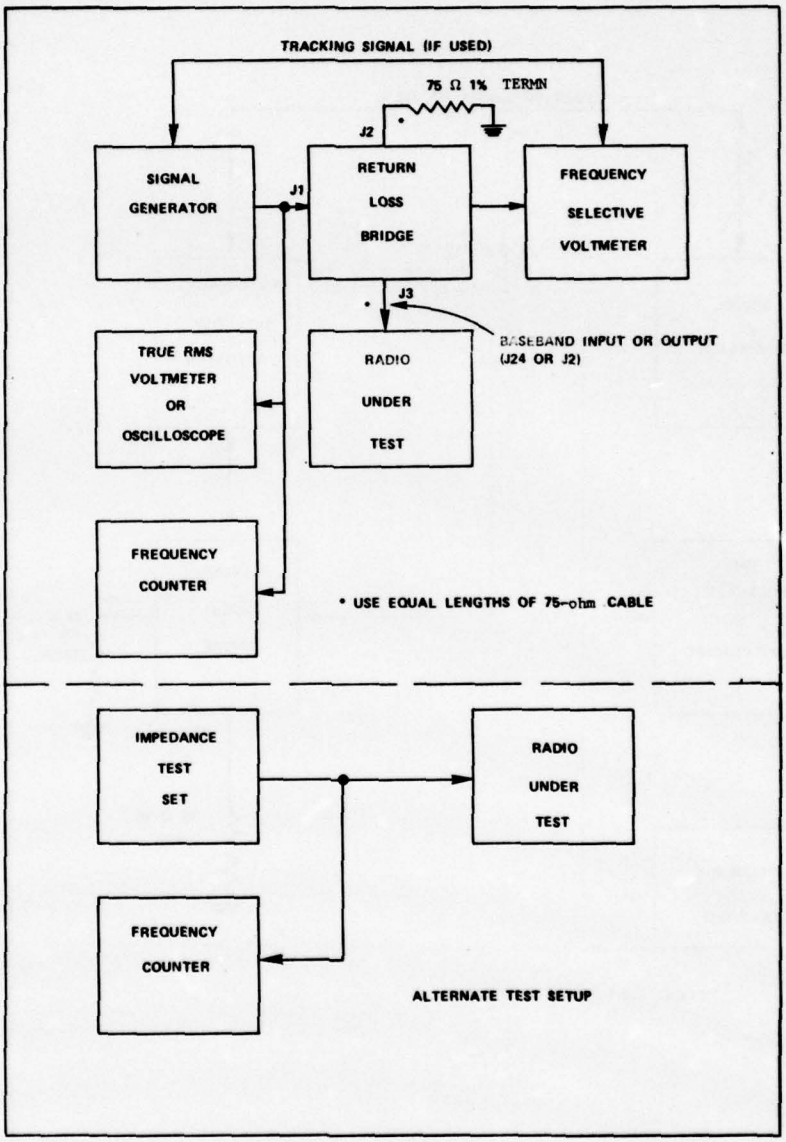


Figure 14-2. Baseband interface (bridge) test setup.

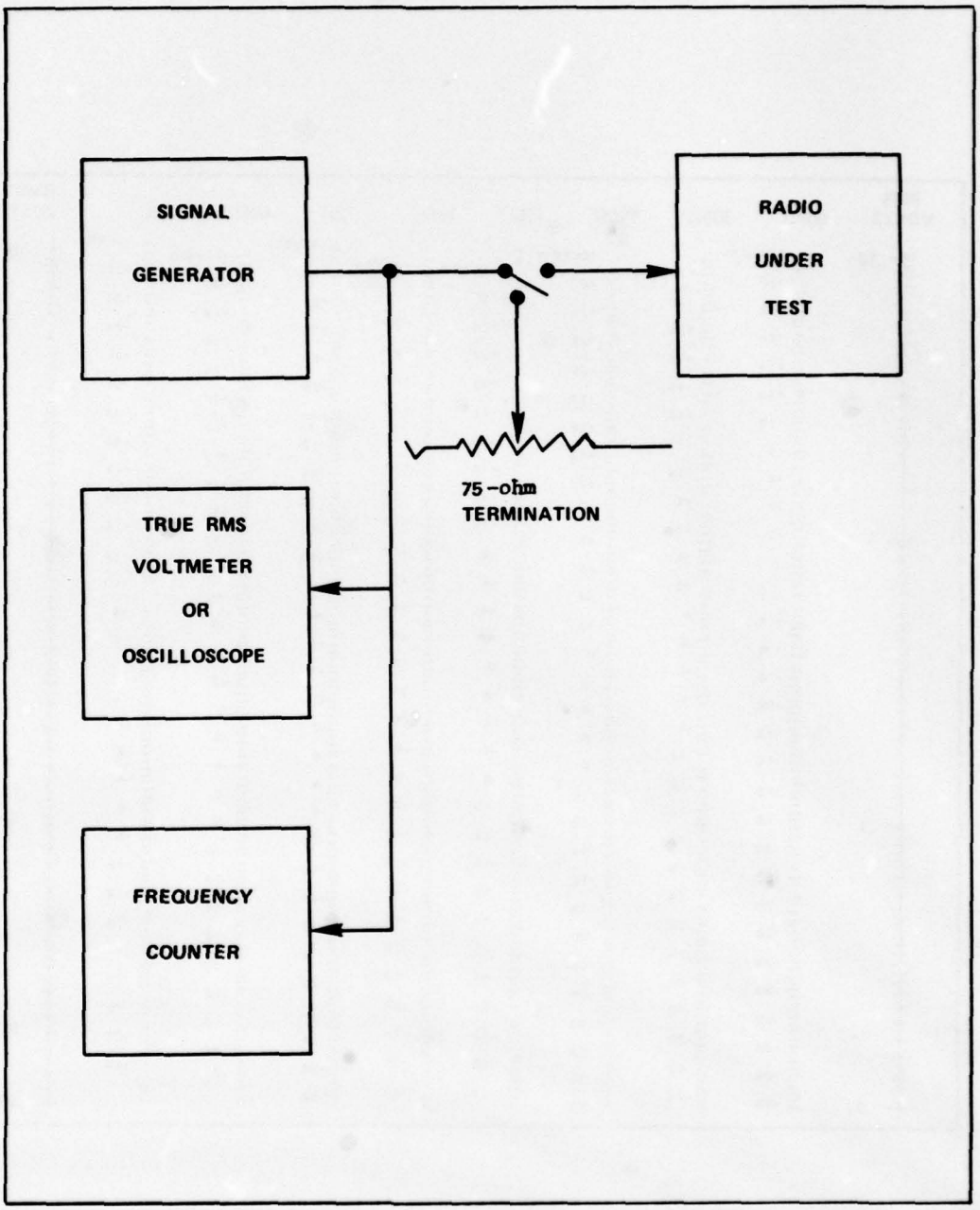


Figure 14-3. Baseband return loss (comparison) test setup.

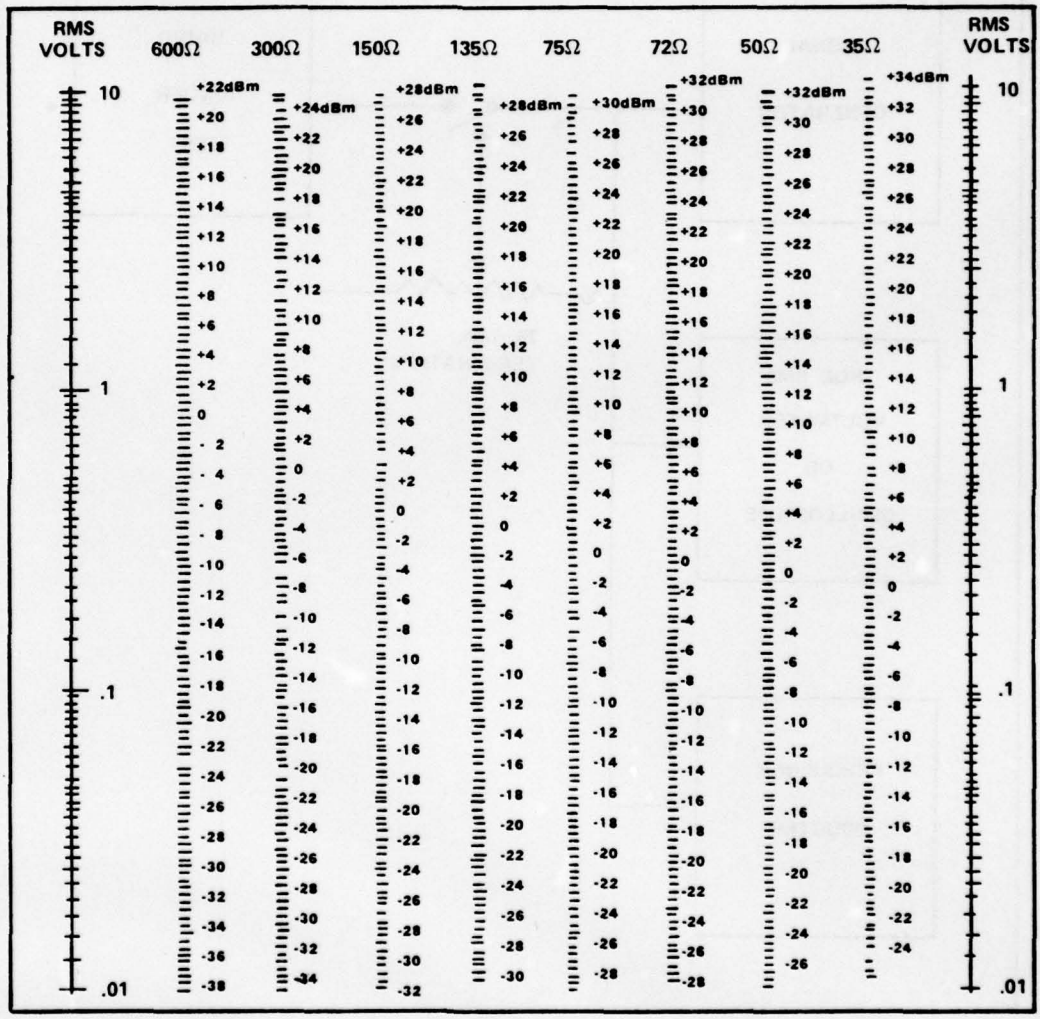


Figure 14-4. Impedance conversion chart.

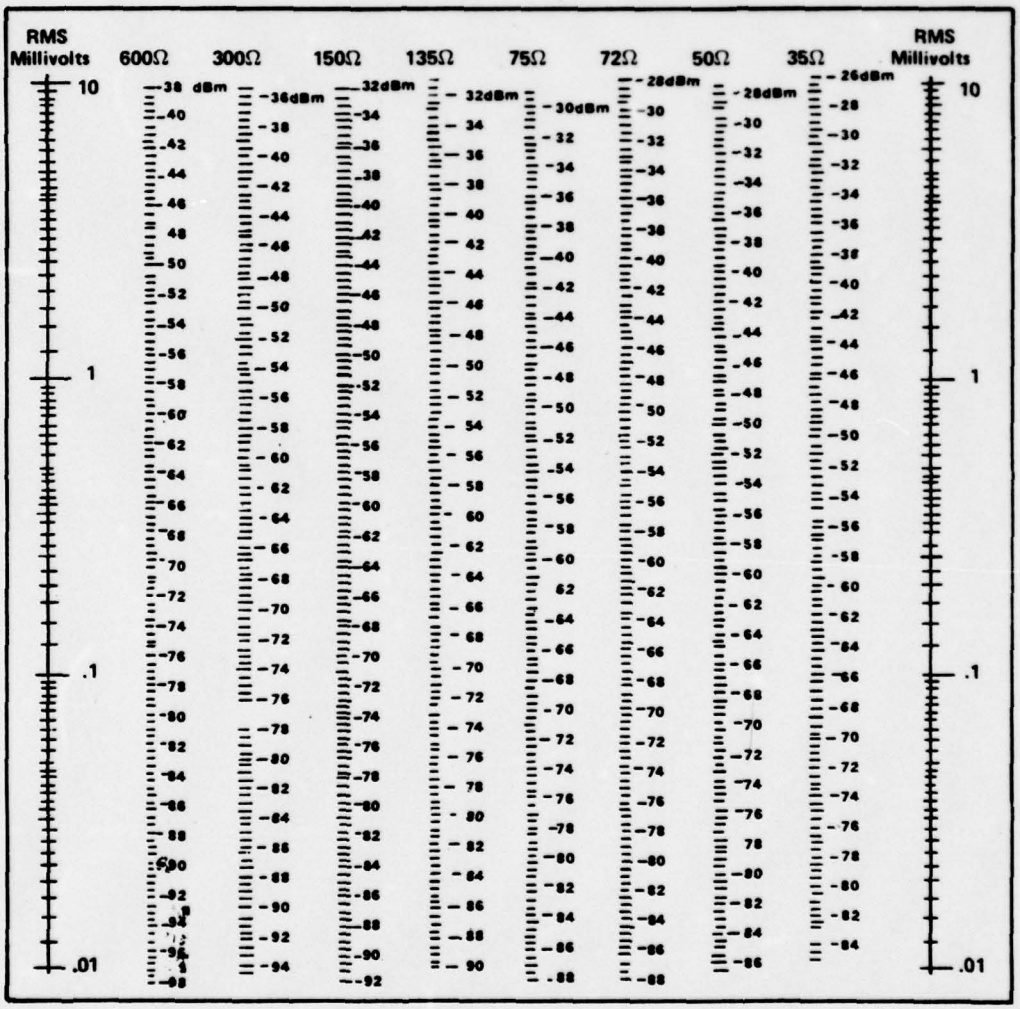


Figure 14-4. Impedance conversion chart. (continued)

CHAPTER 15

DIGITAL RADIO INPUT/OUTPUT (DT-212)

15-1. GENERAL.

a. The purpose of this test is to measure the input/output characteristics of the digital radio AN/FRC-( ).

b. The radio is required to accept serial NRZ polar square wave data with associated polar square wave timing (equal positive and negative duration) at the mission and service channel inputs. The radio should provide NRZ data and timing at the mission and service channel outputs. Figure 15-1 shows a typical timing and square wave NRZ waveform as provided to the input and output of the digital radio.

c. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

15-2. SPECIFICATIONS.

a. The radio shall be capable of accepting one or two synchronous MBS's of equal rates. In addition, the radio shall accept 192 kb/s on the SCBS which shall be integrated with the MBS at the selected rate. (MIL-STD-188-322).

b. The input/output interface shall conform to the requirements of the low level digital interface stated in MIL-STD-188-114 (MBS rates greater than 10 mb/s shall be a design objective).

c. The radio shall accept/provide serial NRZ data and timing at each of the input/output ports. Provisions shall be made to reverse the polarity of the data signal at the input/output ports as a strappable option so that it is clearly indicated that the signal state has or has not been inverted. (MIL-STD-188-322)

d. All equipment shall provide the balanced interface of paragraph 5.1, MIL-STD-188-114. Additionally, the unbalanced interface stated in paragraph 5.2, MIL-STD-188-114 may be provided as a strappable option.

e. As a strappable option, the balanced interface shall be convertible to the unbalanced interface stated in MIL-STD-188-100.

f. The following criteria applies to the input/output characteristics of the AN/FRC-( ). (CCC-74049)

(1) The radio shall provide and accept two synchronous MBS's with associated timing as well as provide and accept a single MBS with associated timing at the rates specified in table 15-1. In addition, the radio shall provide

and accept a 192 kb/s SCBS with associated timing which shall be synchronously time division multiplexed with the MBS(s) at the selected rate.

Table 15-1. Total MBS Rates

TOTAL MBS RATES (mb/s)	PERFORMANCE LEVEL I	PERFORMANCE LEVEL II
3.232	x	--
6.464	x	x
9.696	x	x
12.928	x	x
19.392	x	x
25.856	x	x

(2) The radio shall accept serial NRZ polar square wave data with associated polar square wave timing (equal position and negative duration) at the MBS and service channel inputs. Refer to figure 15-1. The radio shall provide NRZ data and timing at the mission and service channel outputs. The radio shall accept polar square wave timing at the same MBS rate (table 15-2) as the external clock input.

Table 15-2. Mission Bit Stream Rates

NOMINAL MBS RATES (mb/s)	NOMINAL UNIT INTERVAL (msec)	TIMING FREQUENCY (MHz)
3.232	0.3094	3.232
6.464	0.1547	6.494
9.696	0.1031	9.696
12.928	0.0774	12.928

(3) The output impedance for NRZ data and timing shall be 78 ohms ±10 percent (balanced).

(4) For NRZ data and timing, a positive voltage is a logic 1 and a negative voltage is a logic 0. The open circuit voltage at the interface shall be ±4 volts ±10 percent and, when terminated in its characteristic impedance, it shall be ±2 volts ±10 percent.

(5) The data and clock pulse output rise and fall times T_r and T_f (fig. 15-2), when measured between the 10-percent and 90-percent points, shall be greater than 4 nsec and less than 12 nsec for data rates greater than 2 mb/s and shall be less than 100 nsec for data rates 2 mb/s or less.

(6) The trailing edge positive-to-negative transition of the output timing signal shall occur within ±4 percent of the center of the nominal unit interval of the output NRZ data as shown in figure 15-3.

(7) The output data and timing signals shall not have more than ±4 percent jitter (peak-to-peak) of the nominal data unit interval.

(8) The input cable termination shall be 78 ohms ±10 percent for NRZ data and timing inputs (balanced).

(9) At the digital inputs, voltage levels from +0.2 to +7.0 and from -0.2 to -7.0 shall be properly detected and processed without adjustment.

(10) At the digital input, NRZ data and timing signals shall be detected and processed at the zero crossing of the positive-to-negative transition of the timing signal occurring within ±25 percent of the center of the nominal data unit interval of the NRZ data as shown in figure 15-4.

(11) The radio shall operate properly with digital NRZ data and timing inputs each having jitter equal to as much as ±12.5 percent of data unit interval or a peak timing to peak data excursion of 25 percent of the data unit interval.

g. Input/output characteristics shall be as specified in the standard engineering plan or contract specifications.

15-3. TEST EQUIPMENT REQUIRED.

a. BER test sets.

b. Noise generator.

c. PCM simulator.

d. Power splitter/divider.

e. Turnaround mixer.

f. Oscilloscope camera.

g. Multiplexer/demultiplexer TD-1193/TD-1192.

h. TSEC/KG-81.

i. Modulator/demodulator (MODEM).

j. Impedance bridge.

k. RF voltmeter.

l. Jitter meter and jitter generator.

m. Oscilloscope.

15-4. TEST PROCEDURES.

a. Radio Interface.

NOTE: The radio set must interface with the equipment shown in figures 15-5, 15-6, and 15-7 without causing signal degradation. Table 15-3 provides a list of key interface parameters.

Table 15-3. Radio Interface Data

INTERFACE DATA	AN/FRC-( )	AN/FCC-98 TD-1192	TD-1193	KG-81	AN/GSC-24
	INPUT				
WAVEFORMS	NRZ data with timing	NRZ data	NRZ data	NRZ data	NRZ data
IMPEDANCE	78Ω ±10% (balanced)	78Ω ±10% (balanced)	78Ω ±10% (balanced)	78Ω ±10% (balanced)	75Ω ±10% (balanced)
EFFECTIVE SHUNT CAPACITANCE	<15 pF	<15 pF	<15 pF	<15 pF	<10 pF
VOLTAGE LEVEL TERMINATED	±2 ±0.2 volts	±1.5 to ±3.0 volts	±0.2 to ±7.0 volts	±0.05 to ±3 volts	±0.5 volt minimum
MBS DATA RATES	1 or 2 MBS	NA	3.232 mb/s	10 kb/s to 20 mb/s	155 b/s to 10 mb/s
	3.232 mb/s		6.464 mb/s		
	6.464 mb/s		9.696 mb/s		
	9.696 mb/s		12.928 mb/s		
	12.928 mb/s				
SCBS DATA RATE	192 kb/s	192 kb/s	NA	NA	NA
JITTER	±4% of data period	Accepts ±25%	Accepts ±12.5%	Accepts ±24%	Accepts ±20%

Table 15-3. Radio Interface Data (continued)

INTERFACE DATA	AN/FRC-( )	AN/FCC-98 TD-1192	TD-1193	KG-81	AN/GSC-24
	OUTPUT				
WAVEFORMS	NRZ data with timing (1)	NRZ data (1)	NRZ data	NRZ data	NRZ data
IMPEDANCE	78Ω ±10% (balanced)	78Ω ±10% (balanced)	78Ω ±10% (balanced)	78Ω ±10% (balanced)	75Ω ±10% (balanced)
EFFECTIVE SHUNT CAPACITANCE	<15 pF	<15 pF	<15 pF	<15 pF	--
VOLTAGE LEVELS	±0.2 to ±7.0 volts	±3.0 volts	±2 ±0.2 volts	±0.75 to ±1.5 volts	±2.6 (2) ±0.4 volts
MBS DATA RATES	1 or 2 MBS	NA	3.28 mb/s	10 kb/s to 20 mb/s	155 b/s to 10 mb/s
	3.232 mb/s		6.464 mb/s		
	6.464 mb/s		9.696 mb/s		
	9.696 mb/s		12.928 mb/s		
	12.928 mb/s				
SCBS DATA RATE	192 kb/s	192 kb/s	NA	NA	NA
JITTER	Accepts 12.5%	1%	4%	--	10%

NOTES: (1) Accepts external timing. (2) Based on 100Ω source impedance, 78Ω load, ±6 ±1 volts open circuit.

(1) Connect the radio for an IF or RF loop as shown in figure 15-8 and allow 30 minutes for warmup and stabilization.

(2) Set the pattern generator (BER test set) to the input bit rate of the particular type multiplex being used for testing the interface requirements.

(3) Loop the pattern generator output to the maximum multiplex input ports so that the multiplex output represents the MBS rate of the radio under test.

(4) If an RF loop is being used, insert a turnaround mixer and an RF attenuator as shown in figure 15-8. Set the RF attenuator to provide a safe operating level to the mixer and tune the mixer to the center frequency of the receiver.

NOTE: The mixer may be omitted if the transmitter and receiver are tuned to the same frequency.

(5) Adjust the attenuator following the mixer to provide an RSL corresponding to a BER of $5x10^{-9}$ as shown in table 10-1.

NOTES:
1. Before performing the radio interface test, ensure that the multiplex and BER test set provide error free data when placed in a multiplex loop.
2. Since the radio is designed to operate from 3.232 to 25.856 mb/s, certain changes will have to be made to the modulator/demodulator, data recovery unit, and the RF section to accommodate the different bit rates. Refer to the equipment technical manual for the specific changes that must be accomplished.

(6) Set the radio internal multiplex switch for MBS-1 or MBS-2 operation. Note that all alarm indicator lights on the monitor and alarm panel are extinguished.

(7) Using the pattern generator, transmit data on the maximum number of digital multiplex ports as well as 192 kb/s data to the SCBS input.

(8) At the receiver, monitor the data with the error detector. Record any errors on figure 15-9 (USACC Form 633-R).

(9) Reduce the RSL (RF loop) to correspond to an error rate of $5x10^{-2}$ as shown in table 10-1 and repeat subparagraphs (2) through (8) above.

(10) Transmit and record data for approximately 15 minutes.

NOTE: The combined MBS rate and aggregate TDM output rates are shown in table 15-4.

Table 15-4. TDM Data Rate

COMBINED MBS RATE (mb/s)	OUTPUT TDM RATE (AGGREGATE) (mb/s)
3.232	3.488
6.464	6.720
9.696	9.952
12.928	13.184
19.392	19.648
25.856	26.112

(11) Repeat the test using the various equipment shown in figures 15-5, 15-6, and 15-7.

NOTE: If a separate pattern generator and error detector test set are not available, it may be desirable to use the built-in word generator to test the radio and multiplex in a loop configuration.

b. Input/Output Impedance.

(1) Connect the test equipment as shown in figure 15-10a and allow 30 minutes for warmup and stabilization.

(2) Set the output frequency of the bridge to the center of the radio input data rate. As an example, if the radio is being tested for 12.9 mb/s, set the output frequency to 6.4 MHz.

(3) Calibrate the bridge in accordance with the manufacturer's instructions with the output terminated in a 78-ohm ±1 percent precision resistor.

(4) After the bridge has been calibrated, adjust the frequency to 50 kHz and observe that the calibration has not changed. Slowly adjust the bridge frequency upward between 500 kHz and 20 MHz while observing that the calibration remains unchanged over the frequency range.

(5) Initially set the bridge frequency to one-half of the designed data rate of the radio and connect it to the MBS-1 input (fig. 15-10b). With the bridge connected, the impedance should read 78 ohms ±10 percent.

NOTE: In the final computation of the radio set input impedance, an error factor of ±0.2 percent must be allowed for the test equipment. Also if the bridge is designed for 75 or 50 ohms, a matching device will have to be used or the error caused by the mismatch must also be considered in the final computation.

(6) Adjust the capacitance section of the bridge and read the results on the meter. The measured shunt capacitance should be less than 15 picofarads (pF).

(7) Record the results on figure 15-9 (USACC Form 633-R).

(8) If required, measure the impedance and shunt capacitance over the frequency range of 500 kHz to 20 MHz.

(9) Repeat the procedure for each data and timing input port of the radio set.

NOTE: To accurately measure the output impedance of each data and timing port, all signal and output timing should be removed.

(10) Measure and record the output impedance and shunt capacitance of each data and timing port.

NOTE: An alternate test setup is shown in figure 14-3.

c. Voltage Level (Output).

(1) Connect the test equipment as shown in figure 15-11 and allow 30 minutes for warmup and stabilization.

(2) Using the oscilloscope, measure and record the open circuit voltage (unterminated) at each data output port. The measured voltage should be ±4 volts ±10 percent.

(3) In turn, terminate each data output port into a 78-ohm, 1-percent precision resistor and measure the terminated voltage with the oscilloscope. The measured voltage should be ±2 VPP ±10 percent. Record the results on figure 15-9 (USACC Form 633-R).

d. Rise and Fall Times.

(1) Connect the test equipment as shown in figure 15-11 and allow 30 minutes for warmup and stabilization.

(2) Measure the rise and fall times of each data clock pulse output and compare the measured data with that shown in figure 15-1.

(3) Record the results on figure 15-9 (USACC Form 633-R).

(4) To provide a permanent record of the test results, photograph the rise and fall times as displayed on the oscilloscope and mount the photographs on figure 5-2 (DD Form 2093).

(5) Verify that the trailing edge positive-to-negative transitions of the output timing signal occur as shown in figure 15-3. Photograph the test results and mount the photographs on figure 5-2 (DD Form 2093). Ensure that all levels and calibration marks are properly annotated on the data sheet.

e. Output Jitter. (Refer to figures 15-11 and 15-12.)

(1) *Phase jitter meter method.*

(a) Measure the jitter at the radio outputs with an oscilloscope or phase jitter meter having the same data rate and signal characteristics of the radio under test.

(b) Connect the jitter meter for the data rate at which the radio set has been designed to operate and, in turn, connect the meter to each data and timing output as shown in figure 15-11.

(c) If the jitter meter input impedance does not match the designed output impedance of the test point, use an impedance matching device or insert a 10-dB attenuator in front of the meter input to minimize slight impedance variations. In most cases, the jitter will be measured in a high impedance bridging position.

NOTE: The radio set may be looped at IF or RF, if required, to verify the performance in a back-to-back configuration.

(d) If performed with an RF loop, insert an attenuator and turnaround mixer between the transmitter RF output and the receiver RF input as shown in figure 15-8.

(e) Set the test word generator to provide a known pattern at the specified bit rate.

(f) Set up the phase jitter meter in accordance with the manufacturer's instructions, and if phase hits are to be recorded, set the timer for 15 minutes.

(g) Measure and record any jitter for each data and timing output port on figure 15-9 (USACC Form 633-R).

(2) *Oscilloscope method.*

(a) Repeat paragraphs 14-4e(1), (d), and (e).

(b) Connect the oscilloscope, in turn, to each data and timing output as shown in figure 15-11.

(c) If this test is being performed with the MBS and SCBS loaded, set the pattern generator or digital multiplex to the specified bit rate for the equipment under test.

(d) Connect input A of the oscilloscope to the data or timing port to be measured and adjust the oscilloscope for one data transition which begins at the 0-degree point.

(e) Connect channel B input of the oscilloscope to a highly stable oscillator and set the oscillator frequency to the bit rate of the radio under test.

(f) Adjust the oscilloscope A and B inputs for equal amplitudes of the two signals.

(g) Set the vertical position and amplitude controls of the oscilloscope so that 0-, 180-, and 360-degree points are exactly on the center graticule. The phase jitter will appear as a smear of the zero crossing of the curve. The amount of smear in units of degrees on the graticule, is a measurement of the peak-to-peak phase jitter.

(h) Turn the X10 horizontal multiplier on. Peak-to-peak jitter can now be read on the center horizontal graticule as 3.6 degrees per large division on the graticule. In the event a X10 horizontal multiplier is not available on the oscilloscope, switch to 10 µsec per division. This will provide the same display as when using the X10 multiplier.

(i) To provide easier and more accurate reading of the peak-to-peak jitter, increase the vertical oscilloscope sensitivity. At extremely sensitive settings, the vertical position of the display may move. Corrections for this must be made before the amount of jitter can be accurately determined.

(j) Record the amount of jitter for each data and timing output port on figure 15-9 (USACC Form 633-R).

f. Input Voltage.

(1) Connect the test equipment as shown in figure 15-12 and allow 30 minutes for warmup and stabilization.

NOTE: This test may be performed in an IF or RF loop; however, an RF loop would be the preferred method.

(2) At the MBS digital input, set the test word generator for the applicable input bit rate.

(3) Adjust the receive bit error counter to the bit rate corresponding to the transmitted rate.

(4) At the transmit end, initially set the input voltage level to 1 VPP and transmit approximately 1 minute of data. At the receive end, observe that no errors were detected.

(5) At the transmit end, change the input voltage level to +0.2 volt and transmit data for 1 minute. At the receive end, observe that no errors were detected.

NOTE: If an RF loop is used, adjust the input level to the receiver for an RSL corresponding to a BER of 5×10^{-9}.

(6) Increase the input voltage to the transmitter to +7.0 volts and transmit data for approximately 1 minute. At the receive end, observe that the data was received error free.

(7) Reduce the transmitter input voltage to -0.2 volt and repeat paragraph 15-4f(5).

(8) Change the transmit input voltage to -7.0 volt and repeat paragraph 15-4f(6).

(9) Record the number of errors detected at each input voltage level on figure 15-9 (USACC Form 633-R).

g. Data and Timing Input with Jitter.

(1) Connect the test equipment as shown in figure 15-12.

(2) If an RF loop is used, adjust the signal level input to the receiver corresponding to a BER of $5x10^{-9}$ (table 15-4).

(3) Adjust the BER test set to the bit rate at which the radio is to be tested.

(4) Adjust the noise generator PCM simulator or dynamic jitter generator to provide ±12.5 percent of jitter for the data unit interval. For unit interval refer to figures 15-2 and 15-4.

(5) Establish ±12.5-percent jitter to both the MBS and timing inputs as measured with the oscilloscope or jitter meter.

(6) Transmit data for approximately 1 minute, and at the receive end, observe and record the number of errors on figure 15-9 (USACC Form 633-R).

(7) If a PCM simulator or jitter generator having an adjustable amount of jitter is available, use one of these instead of the BER test set.

15-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable elements of the data sheets and compare the measured results with paragraph 15-2. Summarize the test results on figure 3-7 (DD Form 2091).

b. If the radio fails to meet specified performance criteria, advise the responsible activity of required corrective actions.

c. If additional space is needed to record the data, use figure 3-7 (DD Form 2091).

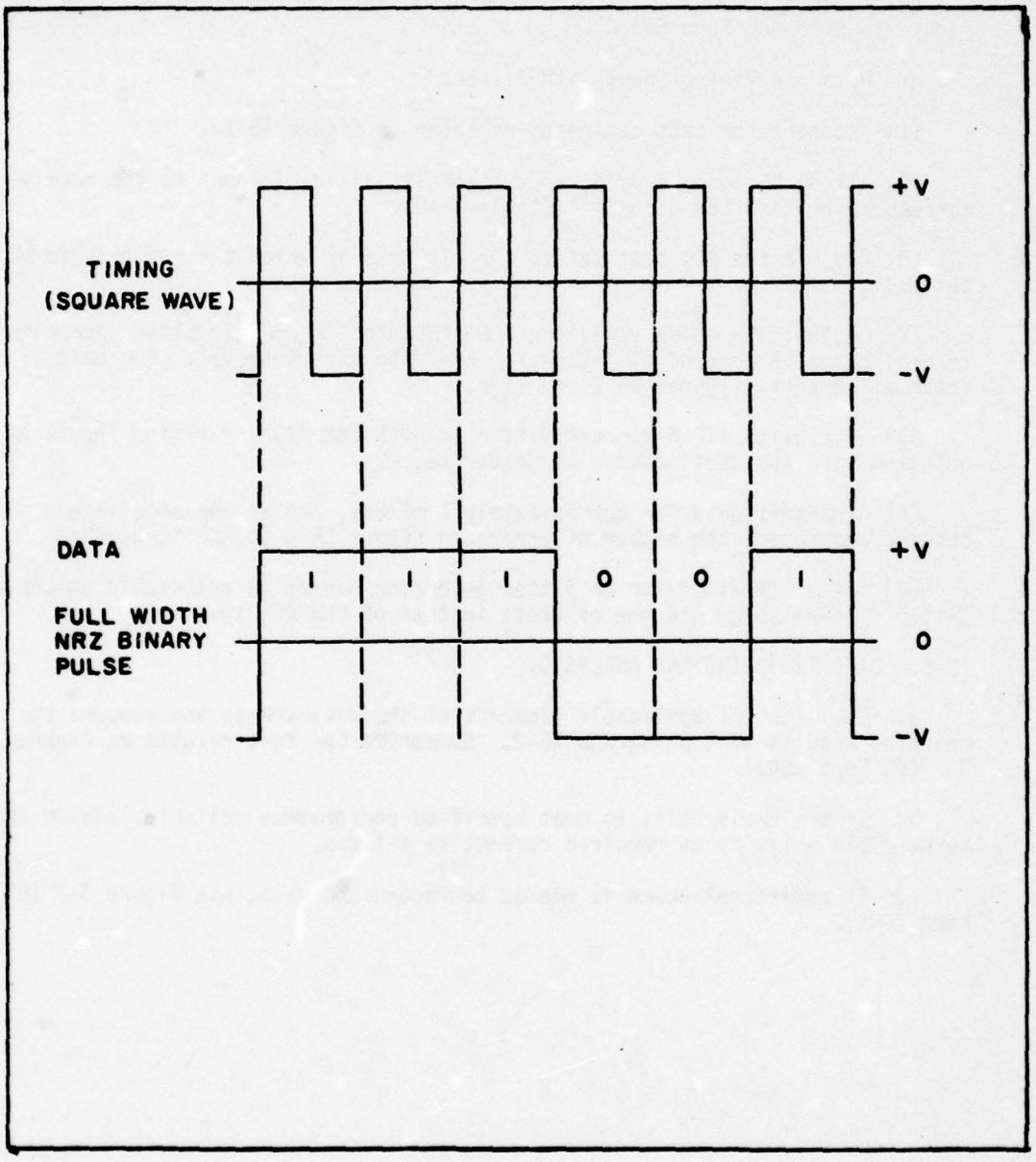


Figure 15-1. Typical timing and NRZ waveforms (AN/FRC-( )).

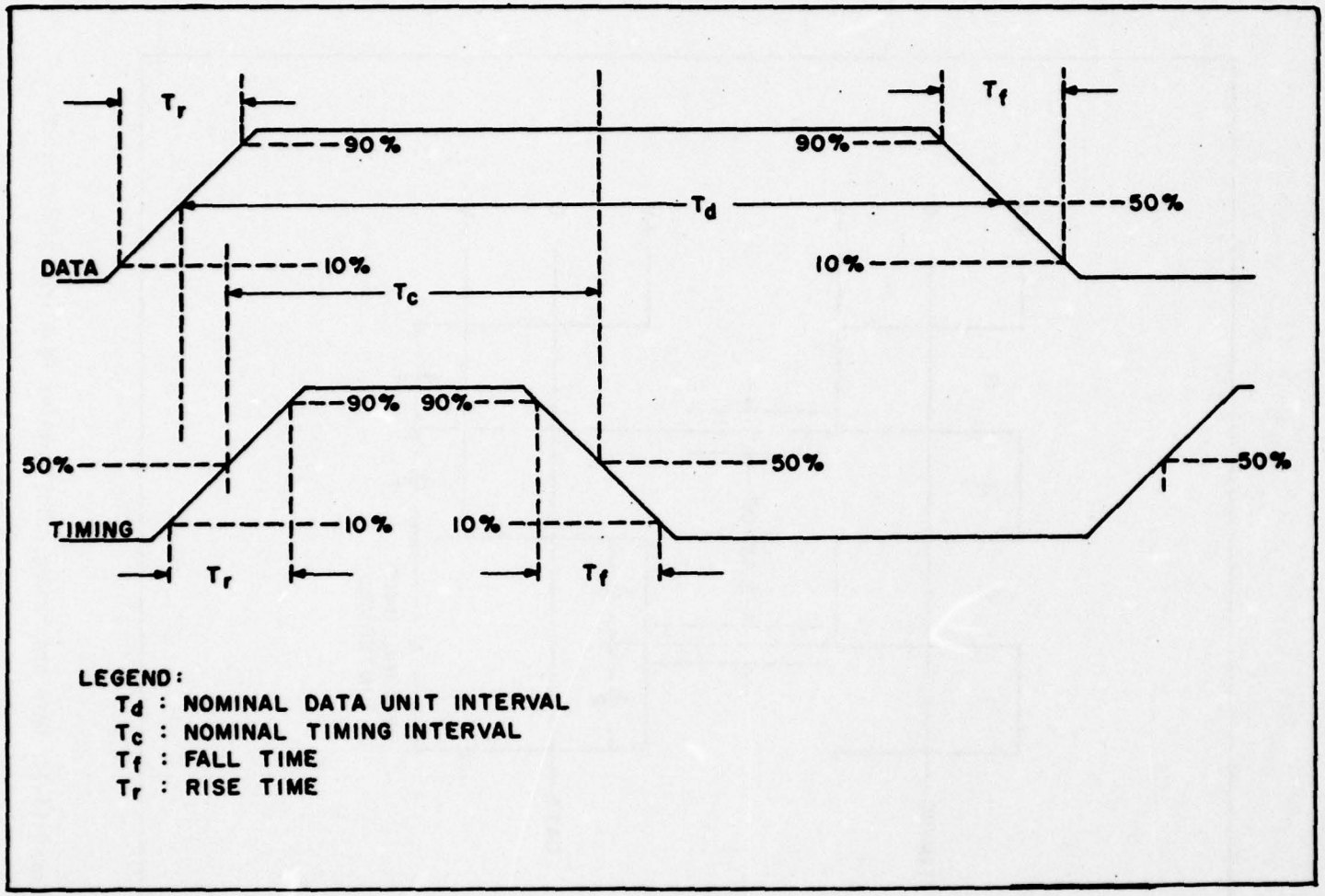


Figure 15-2. Data and timing phase relationships.

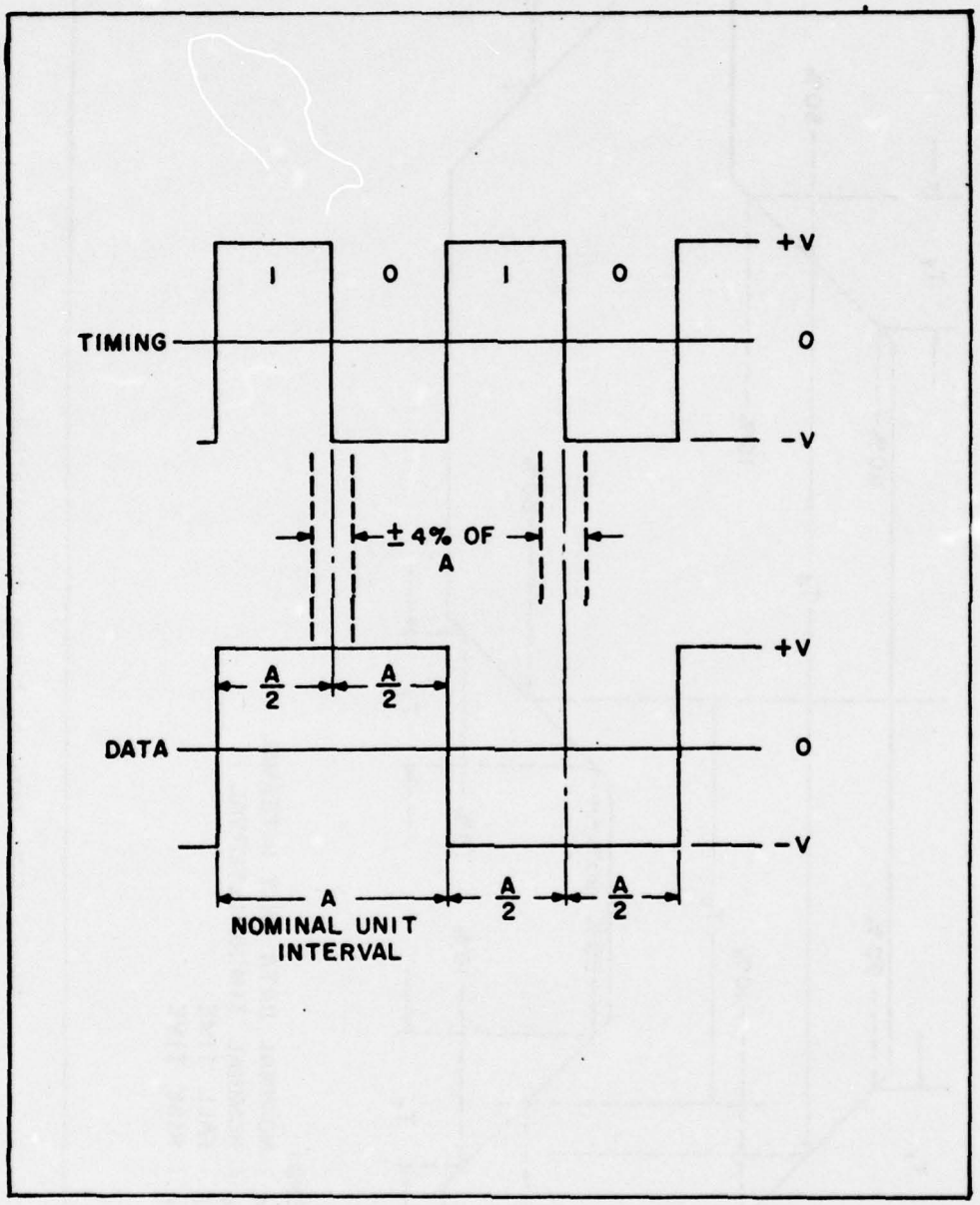


Figure 15-3. Data and timing relationships (phasing) trailing edge.

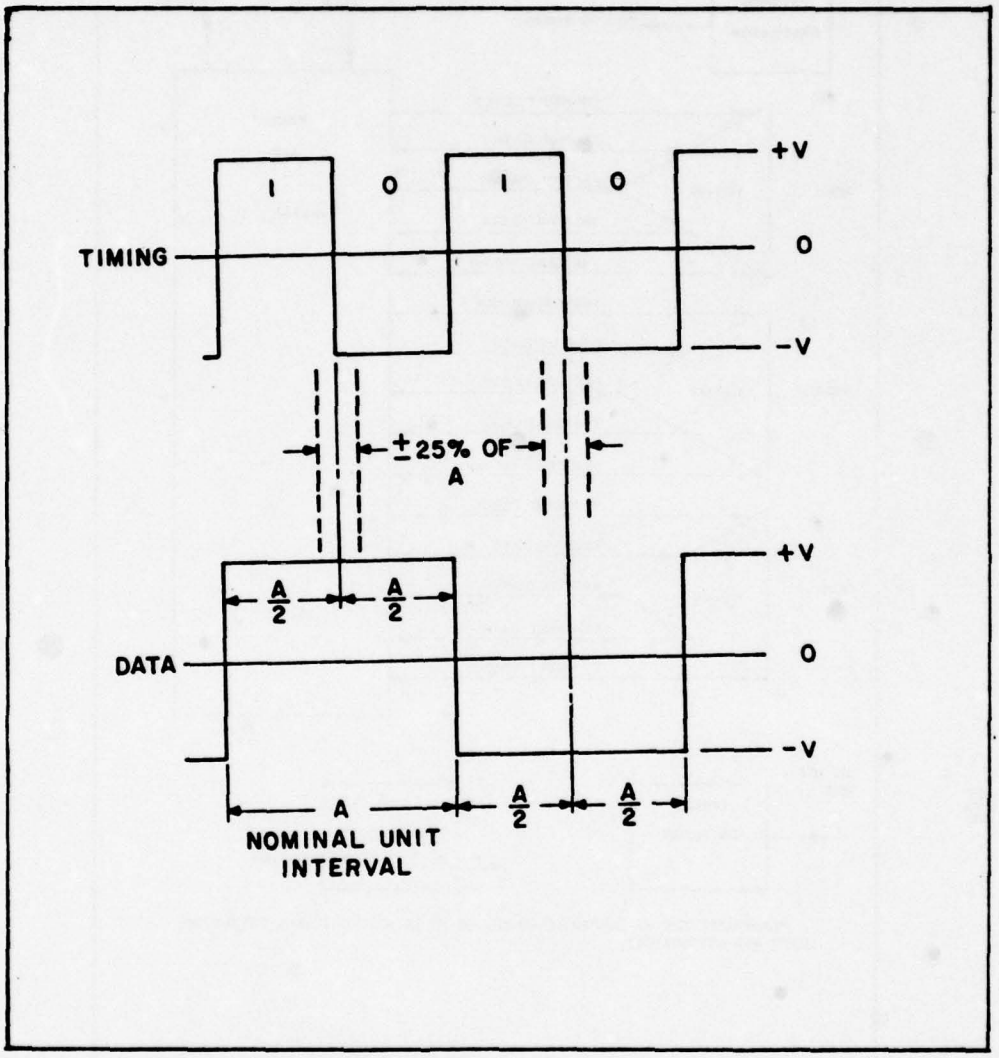


Figure 15-4. Percentage of nominal data unit interval.

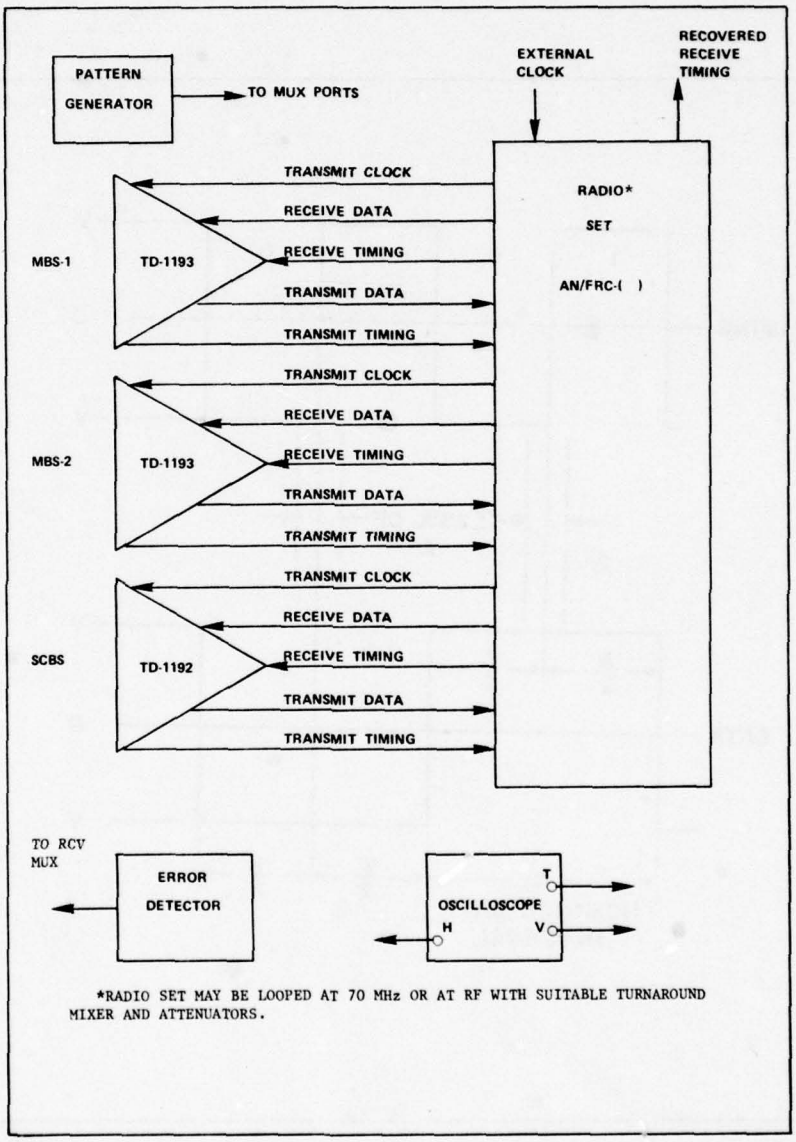


Figure 15-5. Digital radio interface using TD-1193 and TD-1192.

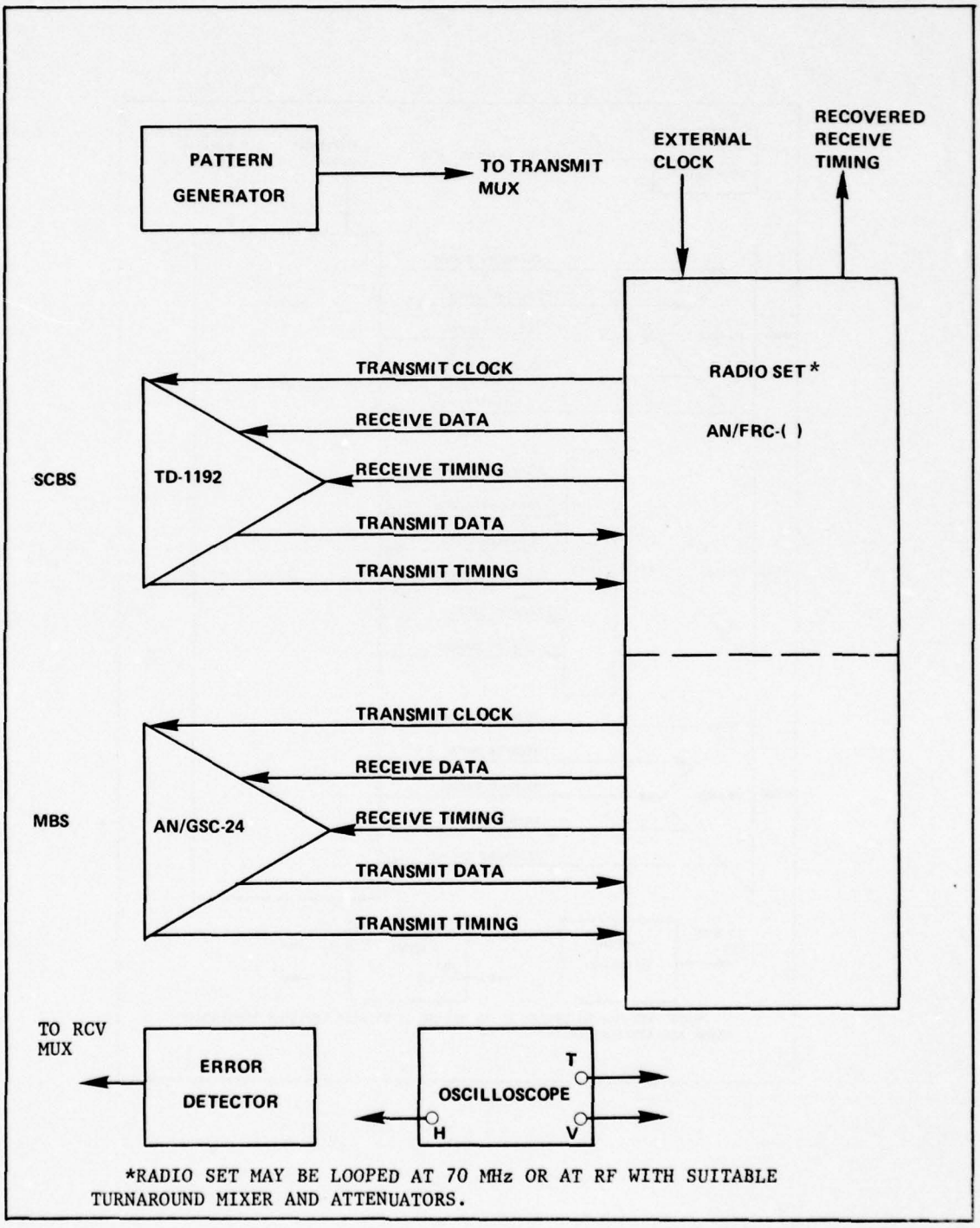


Figure 15-6. Digital radio interface using TD-1192 and AN/GSC-24.

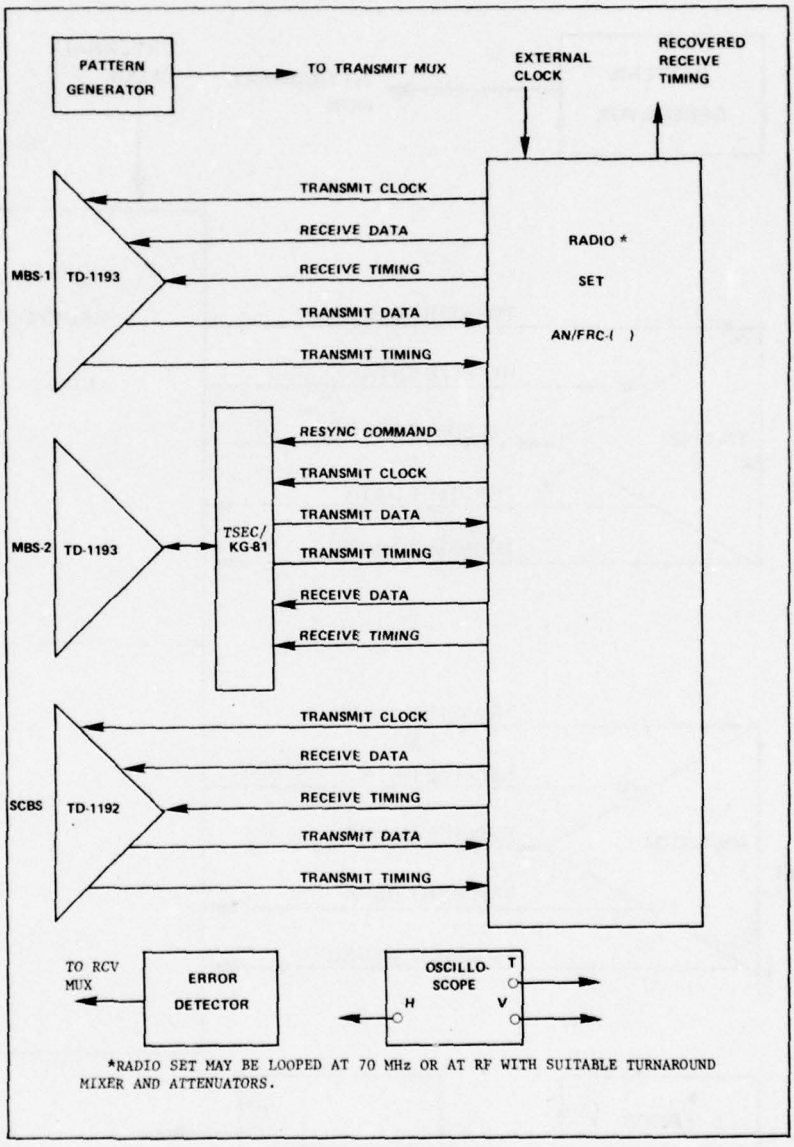


Figure 15-7. Digital radio interface using TD-1193, TD-1192, and TSEC/KG-81.

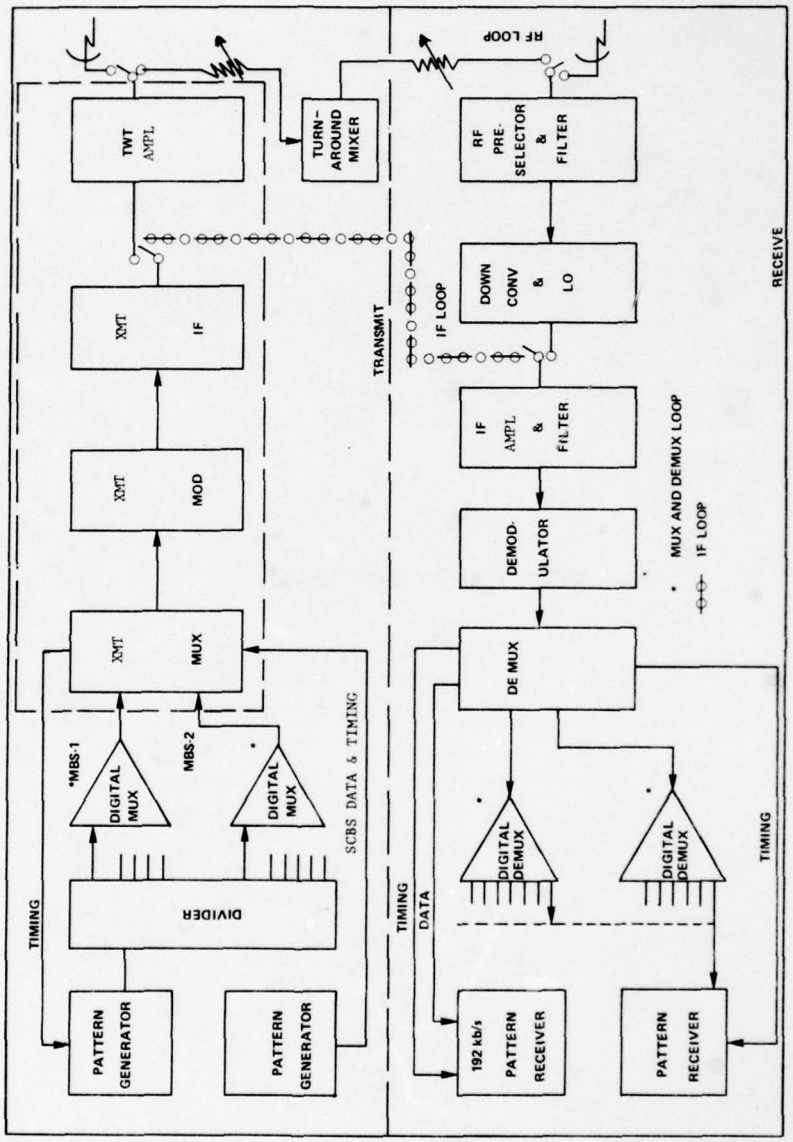


Figure 15-8. Digital radio interface test setup.

INTENTIONALLY LEFT BLANK

DIGITAL RADIO INTERFACE (CCR 702-1-3) DATA SHEET				DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION		TEST ENGINEER
XMTR NO.	XMTR NO.	RCVR NO.	RCVR NO.	AGGREGATE BIT RATE mb/s

INTERFACE EQUIPMENT

EQUIPMENT	RF LOOP ☐ IF LOOP ☐	NUMBER OF BITS TRANSMITTED	ERRORS RECEIVED SIGNAL LEVEL	
			5×10^{-2}	5×10^{-9}
TD-1192				
TD-1193				
KG-81				
GSC-24				

INPUT VOLTAGE

DATA INPUT	VOLTAGE LEVEL	NUMBER OF BITS TRANSMITTED	ERRORS 5×10^{-2}	ERRORS 5×10^{-9}
MBS-1	0.2V			
MBS-1	- 7.0V			
MBS-1	+ 0.2V			
MBS-1	+ 7.0V			
MBS-2	- 0.2V			
MBS-2	- 7.0V			
MBS-2	+ 0.2V			
MBS-2	+7.0V			
SCBS	- 0.2V			
SCBS	- 7.0V			
SCBS	+ 0.2V			
SCBS	+7.0V			

USACC FORM 633-R
1 MAY 79

Page 1

Figure 15-9. Digital radio interface data sheet.

DATA OUTPUT VOLTAGE AND IMPEDANCE					
OUTPUT DATA	OPEN CIRCUIT	TERMINATED	F_c (MHz)	IMPEDANCE	
				Z_o	CAP
MBS-1	VPP	VPP	MHz	Ω	pF
MBS-2	VPP	VPP	MHz	Ω	pF
SCBS	VPP	VPP	MHz	Ω	pF

DATA AND TIMING JITTER				
OUTPUT DATA	OUTPUT JITTER	12.5% JITTER ADDED PHOTO NO.	ERRORS	
			5×10^{-2}	5×10^{-9}
XMT CLOCK				
MBS-1 RCV				
MBS-2 RCV				
SCBS RCV				
XMT CLOCK				
RCV TIMING				
RCV TIMING				
RCV TIMING				
XMT CLOCK				
RISE AND FALL TIMES	nsec	IN SPEC ☐ OUT OF SPEC ☐	PHOTO NO.	
TRAILING EDGE POSITIVE-TO-NEGATIVE	±4%	IN SPEC ☐ OUT OF SPEC ☐	PHOTO NO.	
COMMENTS				

USACC FORM 633-R
1 MAY 79

Figure 15-9. Digital radio interface data sheet. (continued)

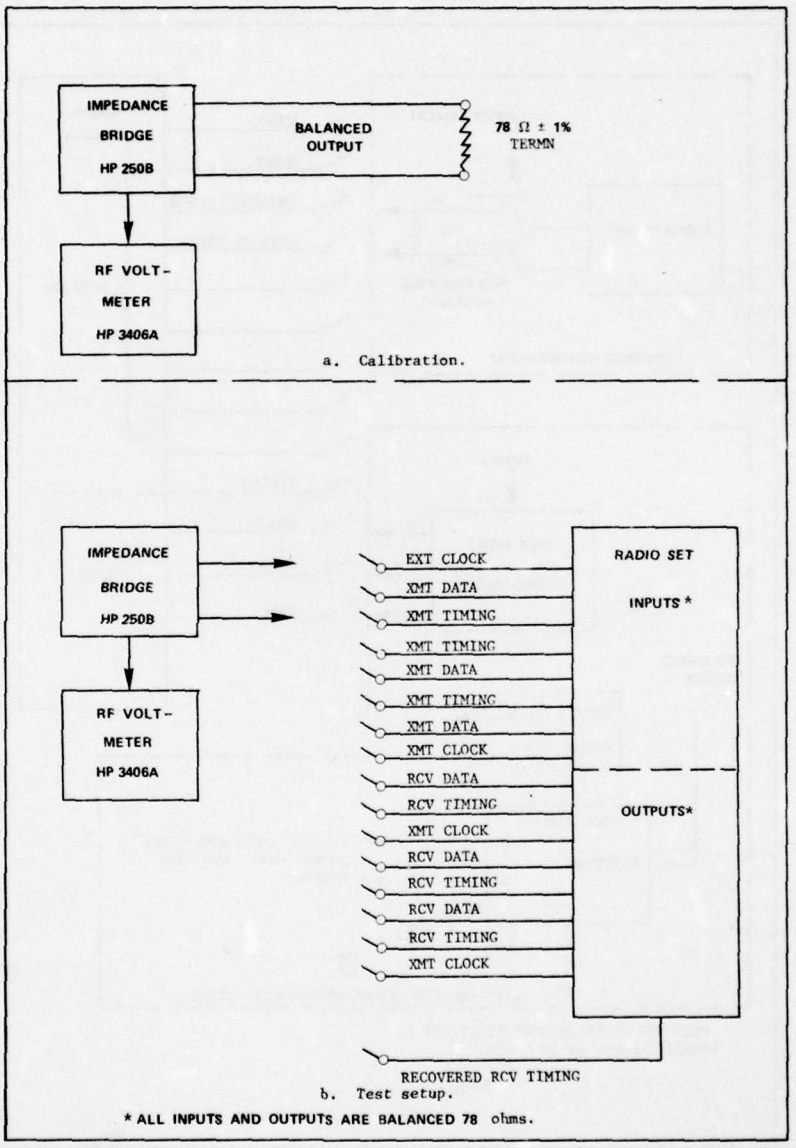


Figure 15-10. Input/output impedance calibration and test setup.

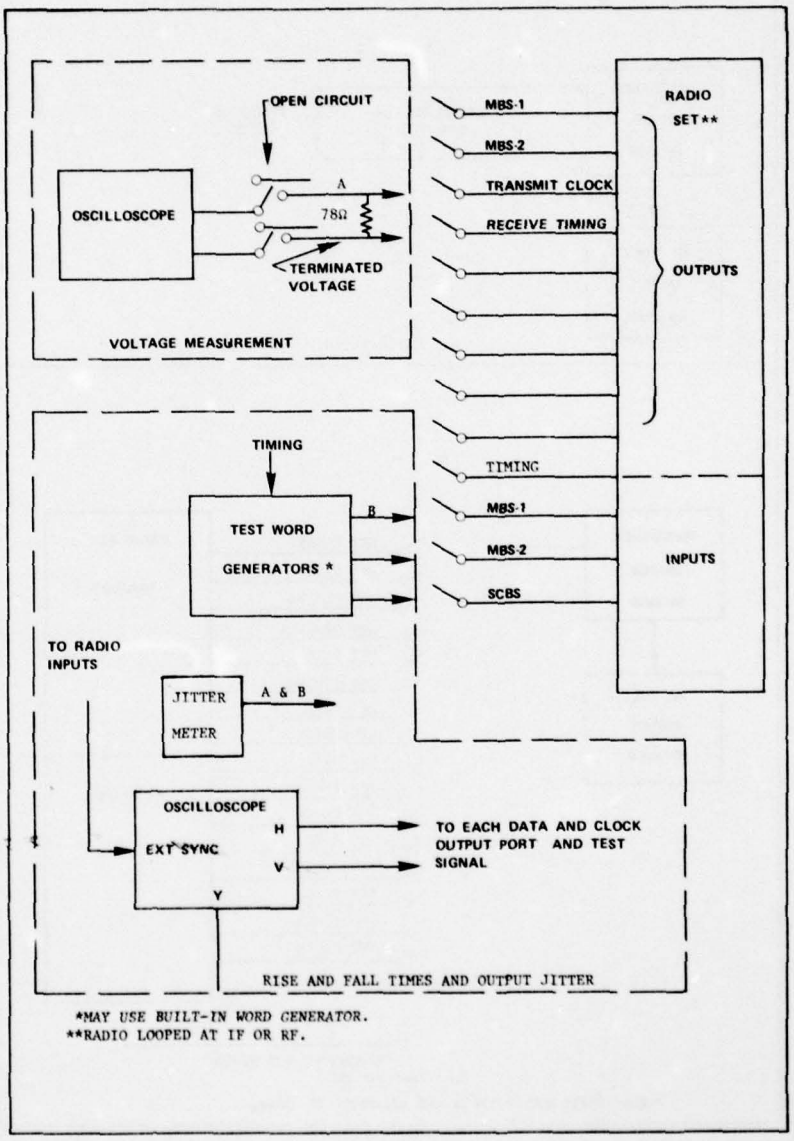


Figure 15-11. Digital radio input/output voltage test setup.

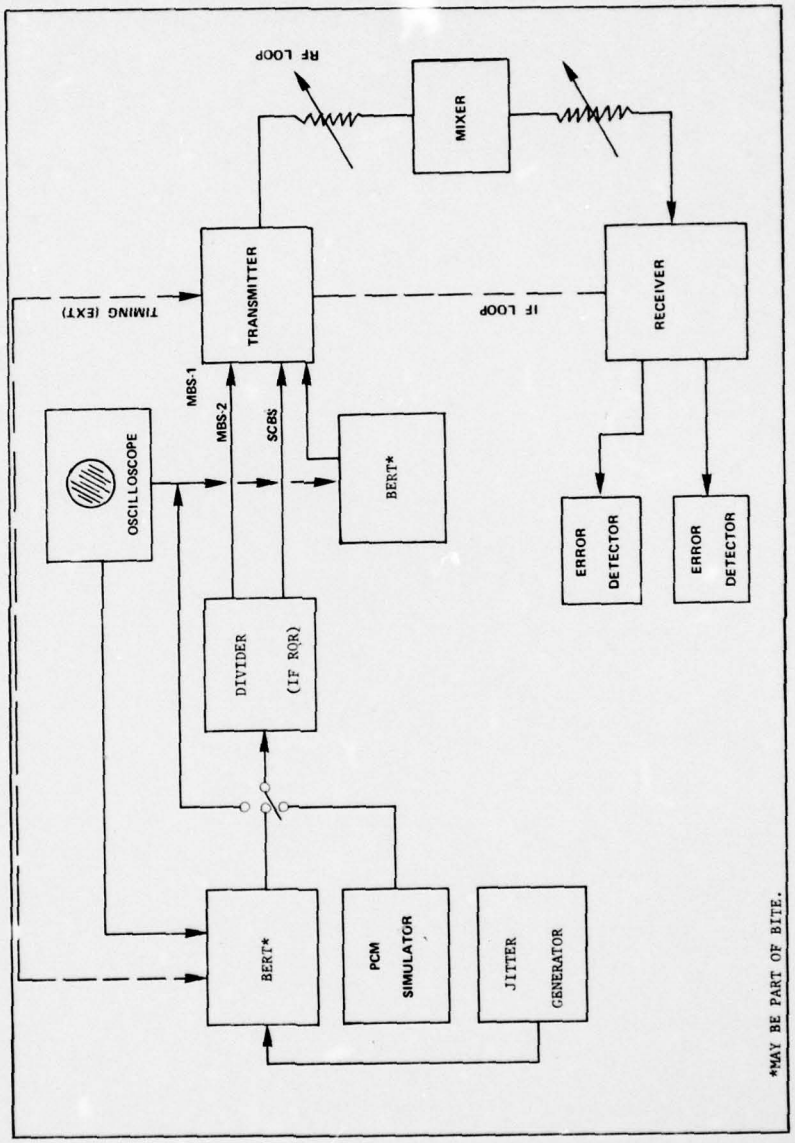


Figure 15-12. Input voltage and data and timing jitter test setup.

CHAPTER 16

SUPERVISORY BASEBAND FREQUENCY RESPONSE, CROSSTALK, AND NOISE PERFORMANCE (DT-213)

16-1. GENERAL.

a. The purpose of this test is to measure the frequency response, crosstalk, and noise performance of the radio supervisory channel.

b. This test does not apply to the fully digitized radio that is scheduled to be introduced into the inventory at a later date.

c. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

16-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) *Frequency response.* The supervisory baseband shall be flat within ±1.5 dB from 300 Hz to 8.0 kHz with all equipment in place and activated.

(2) *Crosstalk.*

(a) Signals of any frequency greater than 12.0 kHz injected into the supervisory baseband input at 0 dBm0 (-15 dBm) shall not appear in the supervisory output at greater than -70 dBm0, measured at the same frequency.

(b) Signals of any frequency less than 8.0 kHz injected into the supervisory baseband input at 0 dBm0 (-10 dBm) shall not cause a response above 12.0 kHz in either baseband output above -70 dBm0.

(3) *Noise performance.* With the message baseband loaded with 12.6 mb/s three-level, partial-response TDM signals with an amplitude of 1.0±0.25 VPP, the noise in the worst 3.1-kHz nominal slot shall not exceed:

(a) 300 to 4000 Hz at -38 dBm0.

(b) 4 to 8.0 kHz at -53 dBm0.

b. The supervisory baseband frequency response, crosstalk, and noise performance shall be as specified in the standard engineering plan or contract specifications.

16-3. TEST EQUIPMENT REQUIRED.

a. Wave analyzer.

b. Frequency selective voltmeter.

c. Spectrum display unit.

d. RF variable attenuators.

e. Turnaround mixer.

f. RF/AF signal generator.

g. X-Y recorder.

h. 12.6-mb/s digital multiplex.

i. BER test set.

j. Transmission measuring set.

k. Oscilloscope.

l. 75-ohm precision resistor.

m. Delay measuring set.

n. RMS voltmeter.

16-4. TEST PROCEDURES.

a. Frequency Response.

(1) Manual method.

(a) Connect the equipment as shown in figure 16-1 and allow approximately 30 minutes for warmup and stabilization.

(b) Typical signal flow diagrams for the supervisory service channel are shown in figures 16-2 and 16-3.

(c) Connect the audio oscillator to a precision 75-ohm resistor and adjust the output level to -10 dBm, at a frequency of 5 kHz.

(d) Adjust the oscillator frequency to 250 Hz and observe that the level is -10 dBm as measured with the voltmeter. Slowly, adjust the oscillator frequency upward to 8.5 kHz while observing that the output level is flat over the specified frequency range ±0.25 dB.

(e) Remove the precision resistor and connect the oscillator output to the service channel input. Adjust the oscillator frequency to 4 kHz at an output of -10 dBm. Ensure that the oscillator is set for a 75-ohm impedance.

(f) Connect the radio set in an RF loop or link configuration as shown in figure 16-1. If an RF loopback is used, adjust the turnaround mixer to the exact center frequency of the receiver at an RSL of approximately 30 dBm.

(g) At the receive end, measure the level of the 4-kHz transmitted tone with the frequency selective voltmeter. The level should read -10 dBm ±0.25 dB. If the level is incorrect, aline the service channel levels in accordance with the equipment technical manual before proceeding with the test.

(h) At the transmit end, change the oscillator frequency to 250 kHz and, at the receive end, measure and record the level on figure 16-4 (DD Form 2095). Slowly increase the oscillator frequency as shown below, while measuring and recording the level of the tone at the receive end.

NOTE: Change frequencies entered on figure 16-4 (DD Form 2095) to those indicated below.

TEST FREQUENCIES (Hz)

250	1000	3000	5000	6500	8000
500	1500	3500	5500	7000	8500
800	2500	4500	6000	7500	

(i) Plot a graph of the test results on figure 3-4 (DD Form 2094) depicting the frequency response versus amplitude of the test signal.

(j) For the opposite direction of transmission, reverse the roles of receive and transmit and repeat subparagraphs (c) through (i), above.

(2) *Automatic method.*

(a) Complete the top portion of the data sheet as applicable.

(b) At the transmit end, calibrate the delay measuring set by connecting the 75-ohm output to a precision 75-ohm resistor as shown in figure 16-5. Allow approximately 30 minutes for warmup and stabilization.

(c) Adjust the output of the delay measuring set to -10 dBm at 4 kHz. Set the sweep range between 250 Hz and 8.5 kHz at a sweep rate of approximately 4 sweeps per minute. Observe the RMS voltmeter as the delay measuring set sweeps across the frequency range. If the test equipment is operating properly, the RMS voltmeter should not vary more than ±0.25 dB throughout the sweep range. Return the delay measuring set to the 4-kHz setting and connect it to the supervisory channel input as shown in figure 16-5, for the transmit end.

(d) At the receive end, calibrate the delay measuring set and the X-Y recorder as shown in figure 16-5.

(e) Connect the oscillator output through the step attenuator, and terminate the output into the delay measuring set for 75 ohms. Adjust the oscillator output for -10 dBm as read on the voltmeter.

(f) Using the delay measuring set frequency counter, calibrate the X-axis of the stripchart recorder between 250 Hz and 8.5 kHz by varying the delay

measuring set carrier frequency and adjusting the recorder controls for a sweep over the frequency range as shown in paragraph 16-4a(1)(h).

(g) Switch the delay measuring set to the receive position and calibrate the recorder Y-axis between -12 and -8 dBm by varying the step attenuator and adjusting the logarithmic/linear amplifier (if used) and recorder controls accordingly, to provide the range on the Y-axis.

NOTE: Always turn off the X-Y recorder servos whenever the pen reaches the end of its travel to preclude damage to the servos.

(h) Once the calibration sequence has been completed, connect the receive test equipment to the supervisory channel output as shown in figure 16-5. The step attenuator may be removed or changed to provide zero attenuation of the incoming signal.

(i) At the transmit end, insert a 5-kHz tone into the supervisory channel at -10 dBm. The alternating current (AC) voltmeter should read -10 dBm unless some impedance irregularities exist. Do not readjust the delay measuring set output.

(j) At the receive end, the voltmeter should indicate a -10 dBm level. Any deviation greater than ±0.25 dB would indicate the channel should be alined as outlined in paragraph 16-4a(1)(g).

(k) At the transmit end, reduce the frequency of the delay measuring set to 250 Hz or until the receive end recorder goes off-scale.

(l) At the receive end, lower the recorder pen onto figure 3-4 (DD Form 2094).

(m) At the transmit end, turn on the delay measuring set sweep and allow the sweep to continue until the pen goes off-scale, or at least to 8.5 kHz.

(n) At the receive end, raise the pen and turn off the X-Y recorder.

(o) Remove all test equipment and restore the system to its normal configuration.

b. Crosstalk.

(1) Connect the radio equipment in RF back-to-back or link configuration as shown in figure 16-6.

(2) Adjust the RSL to -30 dBm and aline the supervisory FM modulator for a peak deviation of 700 kHz with a -15 dBm, 5-kHz test tone inserted into the supervisory channel input (fig. 16-5). Adjust the FM demodulator for a -15 dBm level as read on the RMS voltmeter or frequency selective voltmeter as shown in figure 16-6.

(3) At the transmit end, insert a 12-kHz test tone into the supervisory channel input (fig. 16-6) at -15 dBm.

(4) At the receive end, measure the frequency and level of the test tone with the frequency selective voltmeter or wave analyzer connected to the receive supervisory channel output.

(5) Repeat subparagraphs (3) and (4), above, at 24 and 36 kHz and record the results on figure 16-7 (USACC Form 634-R).

(6) At the transmit end, set the oscillator to 5 kHz at -10 dBm output. Realine the supervisory circuit for a -10 dBm input level.

(7) At the transmit end, slowly increase the oscillator frequency from 250 Hz to 8.0 kHz.

(8) At the receive end, using the wave analyzer or frequency selective voltmeter with spectrum display unit, measure and record the frequency and level of any signal above 12.0 kHz in excess of -70 dBm0 (85 dBm). With the spectrum analyzer connected to the message baseband output, observe that signals introduced into the supervisory channels are isolated from the message baseband. If any signals are observed at the receive message baseband, record the frequency and level of each signal on figure 16-7 (USACC Form 634-R).

(9) Repeat paragraph 16-4b for the reverse direction of transmission and record the results on figure 16-7 (USACC Form 634-R).

c. Noise Performance.

(1) Primary method.

(a) Connect the equipment as shown in figure 16-6, except connect a 12.6 mb/s three-level, partial-response signal to the message baseband input at a level of 1 VPP as shown in figure 1-5.

(b) With the message baseband fully loaded, measure the noise in the supervisory baseband with the frequency selective voltmeter. Ensure that the voltmeter is in 75-ohm termination and 3.1-kHz bandwidth. As a minimum, measure the noise between 300 Hz and 8.0 kHz at the frequencies shown in paragraph 16-4a(1)(h).

(c) Record the results on figure 16-7 (USACC Form 634-R).

(d) Remove all test equipment and restore the system to its normal configuration.

(2) Alternate method.

(a) Use the wave analyzer shown in figure 16-6.

(b) Set the wave analyzer to sweep the frequency range of 300 Hz to 4 kHz. Set the resolution bandwidth to 3 kHz. Connect a 75-ohm load across the analyzer input terminals.

(c) Calibrate the X-Y recorder between -30 and -46 dBm0.

(d) Set the wave analyzer to the sweep position and sweep the 300-Hz to 4-kHz frequency range. Record the test results on figure 3-4 (DD Form 2094).

(e) Calibrate the recorder between -45 and -61 dBm0 and repeat subparagraph (d), above, over the frequency range of 4 to 8.0 kHz.

(f) Remove all test equipment and restore the system to its normal configuration.

16-5. DATA RECORDING AND ANALYSIS.

a. Compare the test results to the applicable specifications in paragraph 16-2. Summarize the test results on figure 3-7 (DD Form 2091).

b. If the unit did not meet specifications, notify the responsible activity of required corrective actions.

NOTE: If the test was performed on a link basis, the specifications in paragraph 16-2 may not be applicable in all cases.

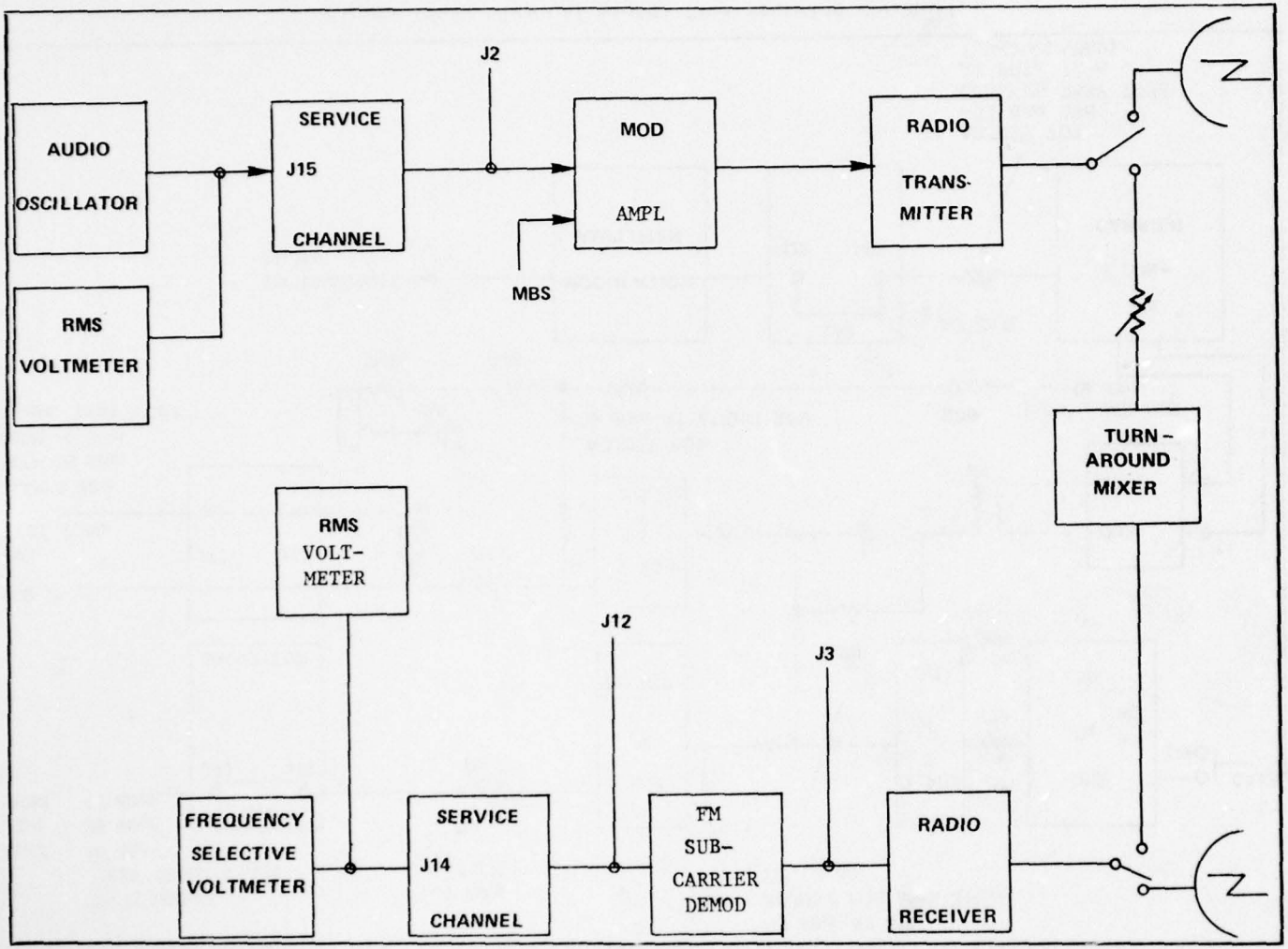


Figure 16-1. Supervisory baseband level vs frequency (manual) test setup.

CCP 702-11

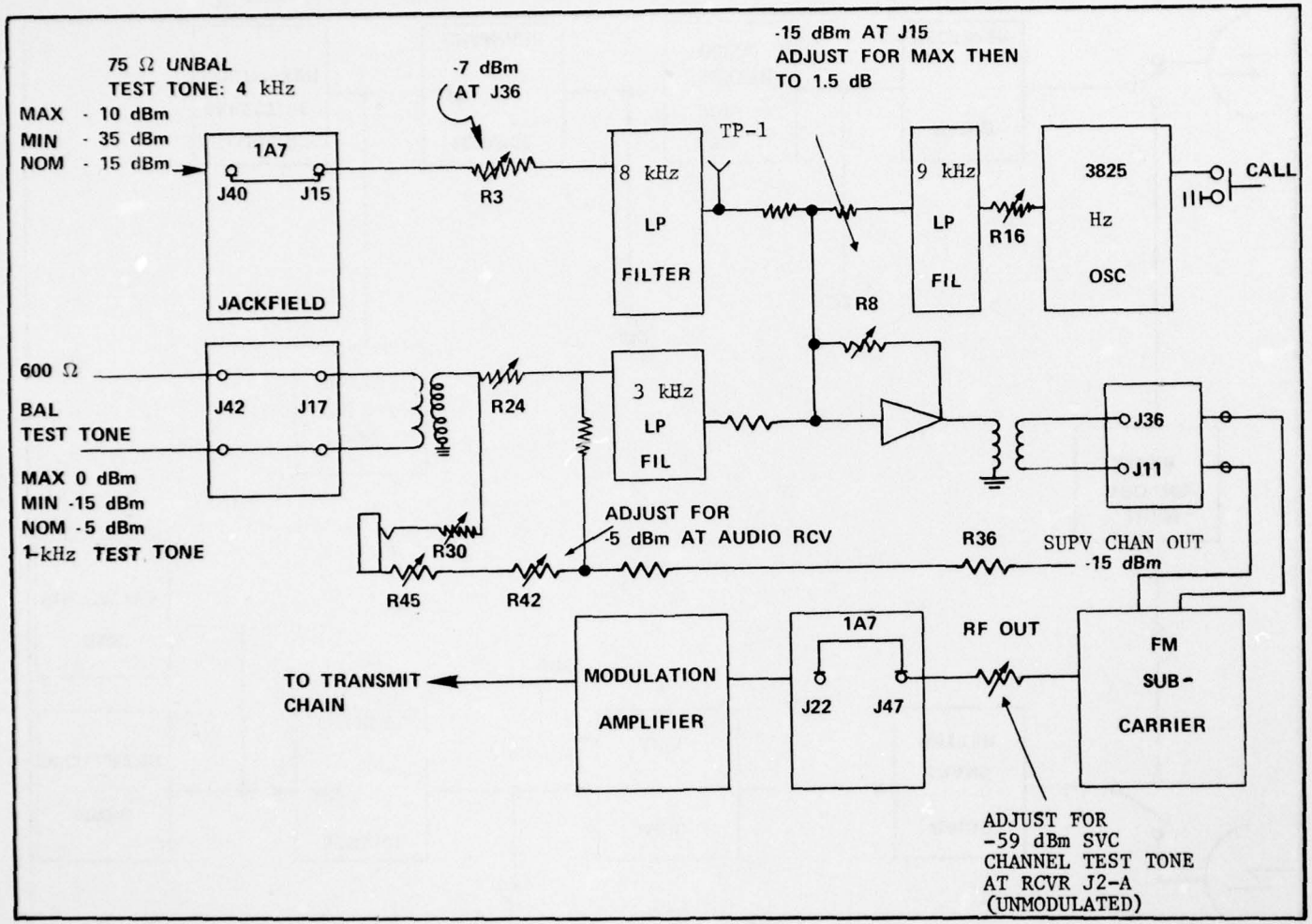
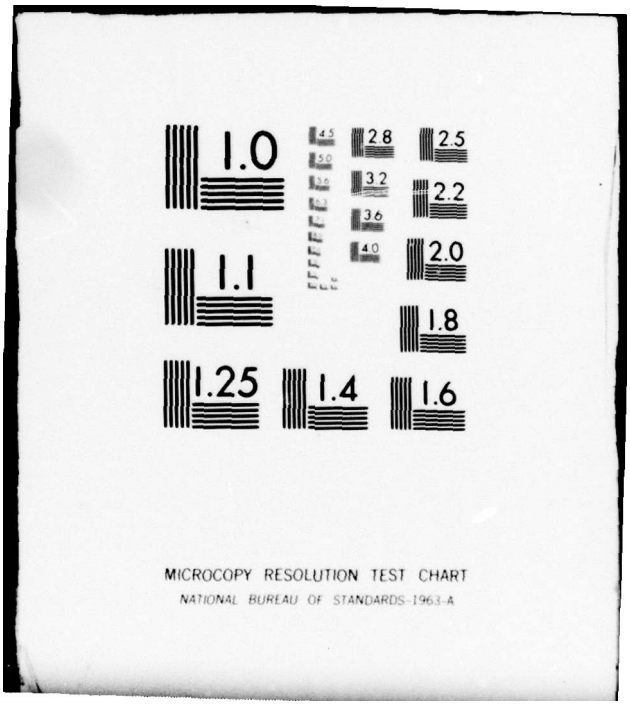


Figure 16-2. Typical signal flow (service channel).

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

3 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

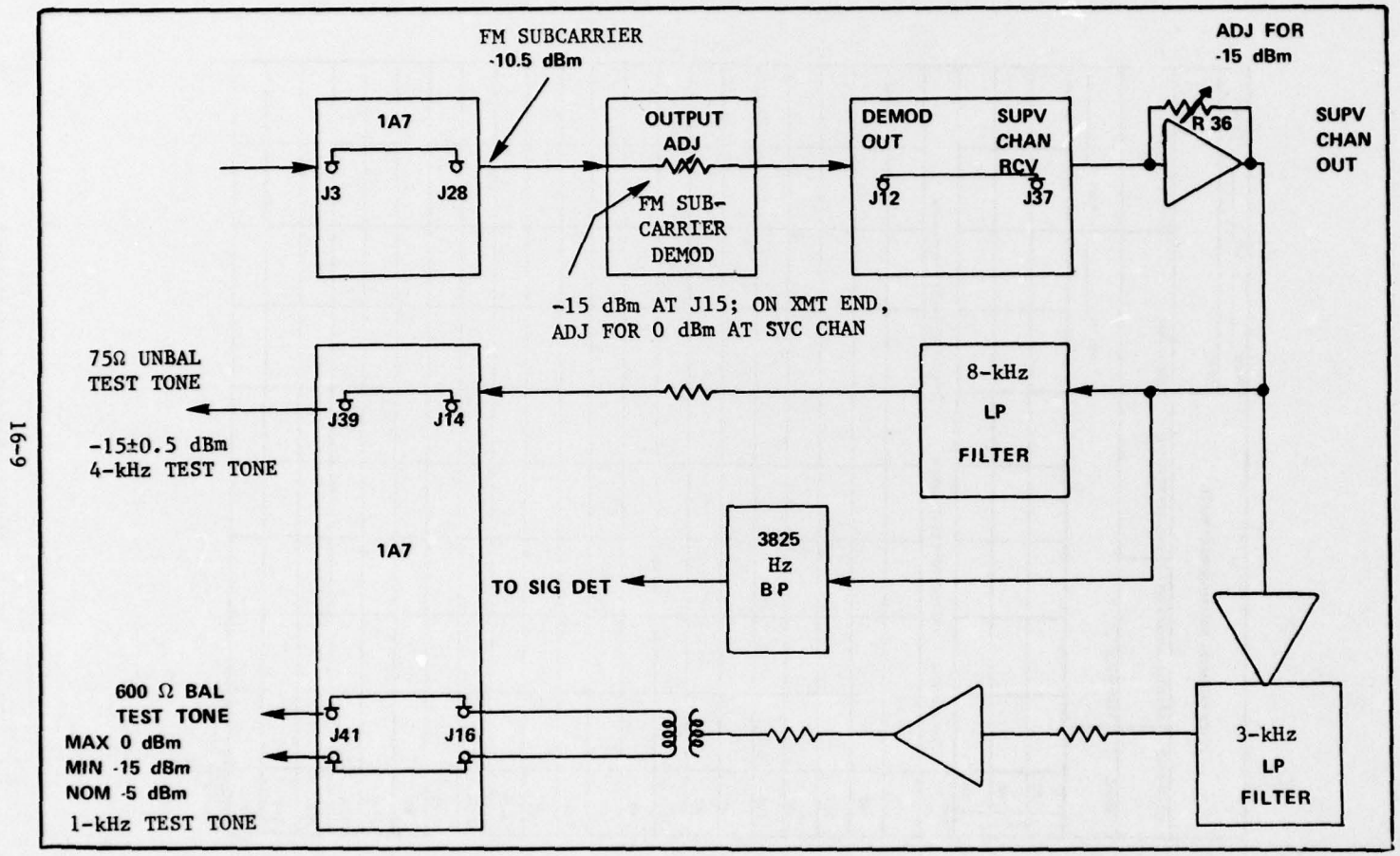


Figure 16-3. Typical signal flow (receive supervisory channel).

VOICE CHANNEL MEASUREMENT DATA			PAGE _____ OF _____ PAGES DATE	
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.
TEST NO.	TEST TITLE:		XMIT TP _____	RCVE TP _____

CHANNEL										
	SG									
	GP									
	CH									
FREQ (Hz)	☐ IMPEDANCE; ☐ TEST TONE LEVEL (dBm); ☐ RELATIVE DELAY (Microseconds)									
100										
200										
300										
400										
500										
600										
800										
1000										
1200										
1400										
1600										
1800										
2000										
2200										
2400										
2600										
2800										
3000										
3200										
3400										
3600										

DD FORM 1 SEP 77 2095

Figure 16-4. Voice channel measurement data.

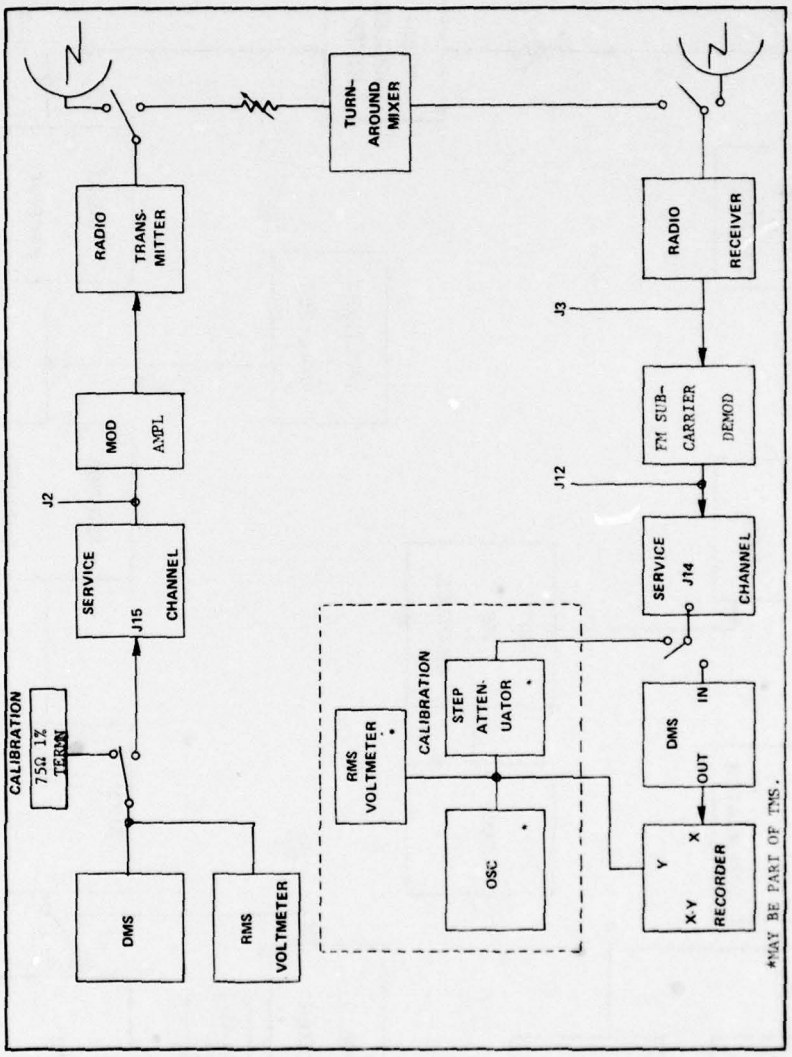


Figure 16-5. Supervisory baseband level vs frequency response (automatic) test setup.

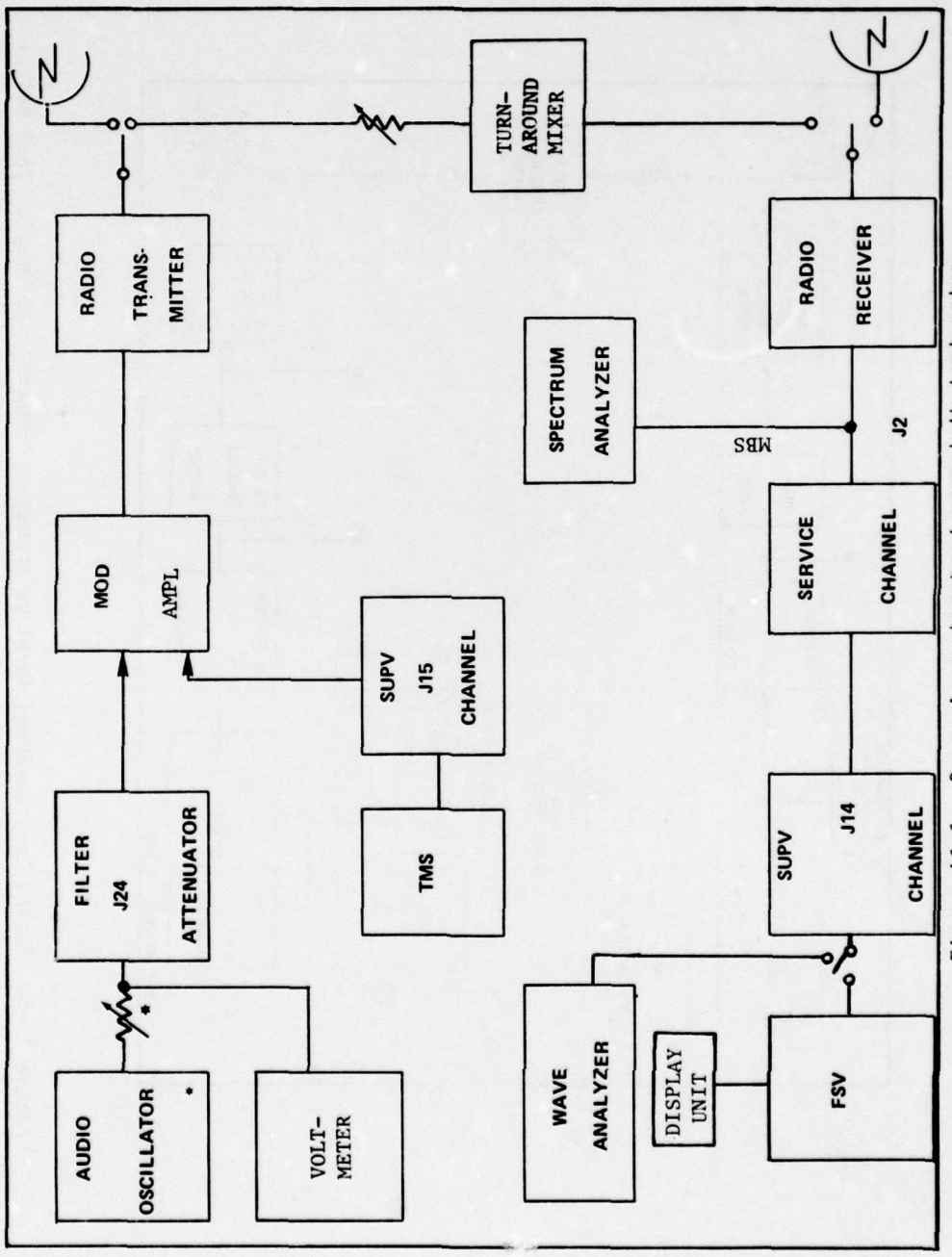


Figure 16-6. Supervisory baseband crosstalk test setup.

SUPERVISORY BASEBAND CROSS-TALK AND NOISE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR NO.	RCVR NO.	CONFIGURATION ☐ RF LOOP ☐ LINK ☐ IF LOOP	
HSL dBm	MOD INPUT LVL dBm	MOD INPUT FREQ REF kHz	DEVIATION (PEAK) kHz

CROSSTALK PERFORMANCE				NOISE PERFORMANCE	
TRANSMIT		RECEIVE		SUPV NOISE	
FREQ kHz	LEVEL dBm	FREQ Hz	LEVEL dBm	MBS LOADED	MBS UNLOADED
12	-16				
24	-15				
36	-15				
0.250	-10 dBm				
0.500					
0.900					
1					
1.5					
2.5					
3.0					
3.5					
4.5					
5.0					
5.5					
6.0					
6.5					
7.0					
7.5					
8.0					
8.5					

COMMENTS

USACC FORM 634-R
1 MAY 79

Figure 16-7. Supervisory baseband crosstalk and noise data sheet.

CHAPTER 17

SUPERVISORY BASEBAND INTERFACE (DT-214)

17-1. GENERAL.

a. The purpose of this test is to:

(1) Measure the input and output impedances of the radio supervisory baseband input and output.

(2) Determine the adjustability of the supervisory baseband input and output.

(3) Measure the return loss at the input and output of the supervisory channel.

b. This test applies primarily to the three-level, partial response radio set AN/FRC-162. It does not apply to the fully digitized AN/FRC-( ) radio set that will be introduced into the inventory at a later date.

c. The specifications contained in paragraph 17-2 apply to the radio set in an RF loop; however, a portion of this test may also be performed on a link basis.

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

17-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) The impedance shall be 75 ohms unbalanced.

(2) The level of adjustability shall be:

(a) Transmit, -10 to -45 dBm test tone per channel.

(b) Receive, -15 dBm ±0.5 dB test tone per channel.

(3) The return loss shall be 26 dB or more over the range of 300 Hz to 8.0 kHz.

b. The supervisory baseband interface shall be as specified in the standard engineering plan or contract specifications.

17-3. TEST EQUIPMENT REQUIRED.

a. Wave analyzer.

b. True RMS voltmeter.

c. Test hybrid CPN 059-0006-505.

d. Decade resistor.

e. 75-ohm precision termination.

f. Audio oscillator.

g. Frequency selective voltmeter.

17-4. TEST PROCEDURES.

a. Input/Output Impedances and Return Loss. There are various ways to measure the input and output impedances and it is possible for each method to provide slightly different results. Therefore, if the test results are to be duplicated in subsequent testing, the original test configuration must also be duplicated. The methods described below are only two of the techniques that may be used.

b. Return Loss Bridge (Method 1).

(1) Connect the test equipment as shown in figure 17-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Initially connect the oscillator to the RMS voltmeter and set the oscillator impedance to 75 ohms. Terminate the oscillator output into 75 ohms through the RMS voltmeter.

(3) Set the oscillator frequency to 300 Hz and establish a reference level on the RMS voltmeter. The suggested reference level is -15 dBm. Slowly increase the oscillator frequency upward to 8.0 kHz and observe that the oscillator output is flat ±0.5 dB over the range of 300 Hz to 8.0 kHz.

(4) Connect the oscillator to the frequency selective voltmeter or wave analyzer and measure the oscillator output level at 300, 1000, 4000, 6000, and 8000 Hz. The level should agree with that obtained in paragraph 17-4b(3).

(5) Connect the oscillator to J1 of the return loss bridge as shown in figure 17-1. The oscillator frequency should be set at 300 Hz with an output level of -15 dBm.

(6) Connect the wave analyzer or frequency selective voltmeter to J4 of the return loss bridge as shown in figure 17-1.

(7) Connect the decade resistor to J3 of the return loss bridge and set the decade resistor for 62.5 ohms.

(8) Connect a precision 75-ohm, 1-percent termination to J2 of the return loss bridge. The return loss reference level as read on the wave analyzer or frequency selective voltmeter should read 26 dB.

NOTE: Use equal lengths of 75-ohm cable, having the same loss characteristics between J2 and J3 of the return loss bridge.

(9) Once the return loss reference has been established for 300 Hz, remove the resistor decade and connect J3 of the bridge to the supervisory baseband input. The level read on the wave analyzer or frequency selective voltmeter represents the return loss of the input at 300 Hz.

(10) Repeat paragraphs 17-4b (6) through (9) for frequencies of 1000, 4000, 6000, and 8000 Hz. Record the test results on figure 17-2 (USACC Form 690-R).

(11) To measure the supervisory channel output impedance, remove all pilot and other signals that may interfere with the measurement. This is best accomplished by turning the radio set off and repeating paragraphs 17-4b (2) through (10). Record the test results. Remove all test equipment.

c. Comparison (Method 2).

(1) Connect the test equipment as shown in figure 14-4.

(2) Terminate the audio oscillator into a precision 75-ohm termination. Set the output level to -15 dBm at a frequency of 300 Hz.

(3) Connect the oscillator output to the supervisory channel input and observe the change in level as read on the RMS voltmeter.

(4) Repeat paragraphs 17-4c (2) and (3) for frequencies of 1000, 4000, 6000, and 8000 Hz.

(5) Calculate the return loss from the signal level change for each frequency and record the test results.

(6) For the supervisory output measurement, turn off the radio set and repeat paragraphs 17-4c (2) through (5). Record the test results.

NOTE: An impedance conversion chart is shown in figure 14-4. Table 5-1 provides a ready reference for return loss conversion.

d. Supervisory Baseband Adjustability.

(1) Configure the equipment as shown in figure 16-6.

(2) Initially set the oscillator output to -10 dBm at a frequency of 5 kHz. Connect the oscillator output to the supervisory channel input.

(3) Perform the adjustments on the transmit supervisory subsystem as specified in the equipment technical manual.

(4) At the receive end, adjust the supervisory baseband level control for -15 dBm ±0.5 dB as measured with the frequency selective voltmeter in the 75-ohm terminated position.

(5) Record this level.

(6) Adjust the oscillator output to -15 dBm and record the level of the received tone. Repeat paragraphs 17-4d (4) through (6) at input levels of -20, -30, -40, and -45 dBm. Record each level setting.

17-5. DATA RECORDING AND ANALYSIS.

a. Review all test results to ensure that they are valid and all requirements have been met. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet any of the required specifications, notify the responsible activity of required corrective actions.

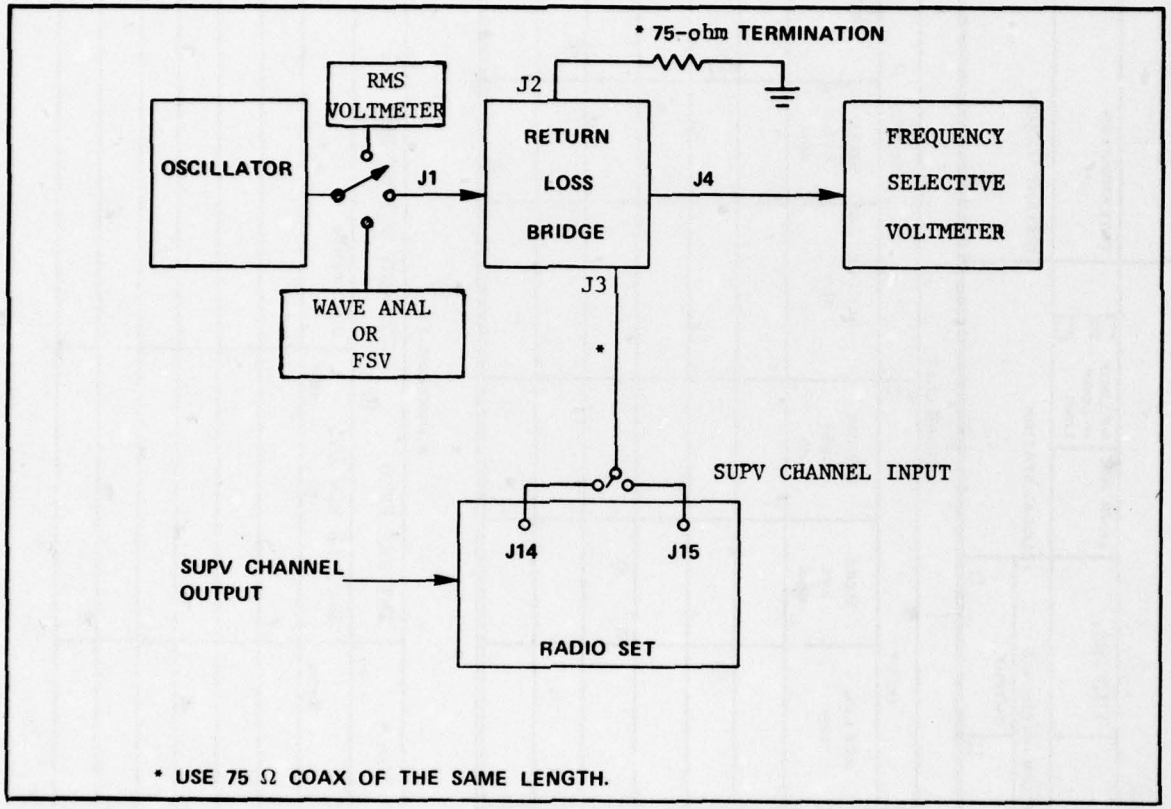


Figure 17-1. Supervisory baseband return loss (bridge) test setup.

CCP-702-11

SUPERVISORY BASEBAND INPUT CHARACTERISTICS (CCR 702-1-3) DATA SHEET				PAGE OF PAGES DATE (DAY, MO, YEAR)
LINK NO.	XMTR NO.	RCVR NO.	RF LOOP ☐ IF LOOP ☐ LINK ☐	TEST ENGINEER
DESIGN IMPEDANCE		LOCAL STATION		DISTANT STATION
INPUT Ω	OUTPUT Ω			

RETURN LOSS

FREQ Hz	INPUT			OUTPUT		
	REF LVL dBm	MEAS LVL dBm	RETURN LOSS dB	REF LVL dBm	MEAS LVL dBm	RETURN LOSS dB
300						
1000						
4000						
6000						
8000						

ADJUSTABILITY

XMT REF LVL dBm	XMT REF FREQ Hz	SUPV RCV OUTPUT REF LVL dBm

XMT LVL dBm	SUPV BB RCV LVL dBm	DIFFERENCE dB
-10		
-15		
-20		
-30		
-40		
-45		

COMMENTS

USACC FORM 690-R
1 MAY 79

Figure 17-2. Supervisory baseband input characteristics data sheet.

CHAPTER 18

RADIO ORDERWIRE (DT-215)

18-1. GENERAL.

a. The purpose of this test is to measure and verify the input and output characteristics of the radio orderwire.

b. Portions of the test may be performed on a link basis; however, the specifications outlined in paragraph 18-2 are based on an RF loopback. The entire procedure will be conducted for both directions of transmissions.

c. This test is primarily applicable to the AN/FRC-162 radio modified for digital transmission.

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

18-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) Tone signaling shall be used to sound a buzzer, bell, or horn and to close a pair of accessible dry contacts or equivalent.

(2) Audio input and output shall be four-wire.

(3) Impedance shall be 600 ohms with a 20-dB return loss over the frequency range of 350 to 3000 Hz for send and receive.

(4) Test tone adjustability shall be from 0 to -15 dBm for send and receive.

(5) Frequency response shall be within ±3 dB between 350 and 3000 Hz, without signaling equipment.

(6) The minimum signal to flat-weighted noise ratio shall be:

(a) 30 dB at an RSL of -30 dBm.

(b) 26 dB at an RSL of -71 dBm.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

18-3. TEST EQUIPMENT REQUIRED.

a. Impedance bridge.

b. Audio oscillator.

c. RMS voltmeter.

d. Frequency selective voltmeter/wave analyzer.

e. X-Y recorder.

f. Delay measuring set.

g. Transmission measuring set.

h. Noise measuring set.

i. 600-ohm precision resistors.

j. AC voltmeter.

18-4. TEST PROCEDURES.

a. Impedance. Input and output impedances and different test methods will invariably provide different results. Therefore, an identical test setup must be used when any attempt is made to duplicate test results.

(1) Vector impedance bridge.

(a) Connect the test equipment as shown in figure 18-1 and allow approximately 30 minutes for warmup and stabilization.

(b) Set the impedance bridge for a frequency of 350 Hz as measured with the frequency counter.

NOTE: Once the proper frequency has been established, remove the frequency counter and RMS voltmeter from the circuit.

(c) Set the range switch on the bridge to the 50-Hz to 500 kHz-position and connect the bridge input to the radio orderwire input.

(d) Adjust the bridge according to the manufacturer's literature and read the input impedance at 350 Hz.

(e) Change the bridge frequency to 1500, 2000, and 3000 Hz. Measure and record the impedance at each frequency shown in figure 18-2 (USACC Form 635-R).

(f) Repeat paragraphs 18-4a(1) (b) through (e) for the radio orderwire output. For the output, the radio should be turned off or the FM subcarrier demodulator (J12) should be terminated in its characteristic impedance.

(2) Comparison method.

(a) Connect the audio oscillator to the radio receive orderwire output terminals rather than a level measuring set (part of transmission measuring set) as for a frequency response test.

(b) Connect the audio oscillator to a 600-ohm precision resistor and adjust the oscillator frequency to 350 Hz at a level of -15 dBm (fig. 18-3, calibration).

(c) Measure the open circuit output level (V_2) to ensure that the oscillator has an output impedance (R_o) of 600 ohms as shown in figure 18-3. Place a 600-ohm resistor across the oscillator output level and measure and record the output level (V_2) on figure 18-2 (USACC Form 635-R). If the oscillator output is 600 ohms, V_2/V_1 should equal 2. If V_2/V_1 does not equal 2, calculate the oscillator output impedance (R_o) from:

$$R_o = \frac{V_2 - V_1}{V_1} \times 600 \text{ ohms}$$

Use this value to calculate the input circuit terminal impedance:

$$\frac{V_1}{V_2} - V_1 \times R_o \text{ ohms}$$

(d) Remove the precision resistor and RMS voltmeter and connect the audio-oscillator output to the radio orderwire input as shown in figure 18-4. Calculate the input impedance as outlined in paragraph 18-4a(2)(c), and record the results.

(e) Repeat paragraphs 18-4a(2) (b) through (d) at the frequencies of 1500, 2000, and 3000 Hz. Record the calculated impedance on figure 18-2 (USACC Form 635-R). A sample calculation of the test results would be:

$$V_1 = 0.775V \text{ (terminated)}$$

$$V_2 = 1.55V \text{ (open circuit)}$$

$$\text{Terminal impedance} = \frac{0.775}{1.55} - 0.775 \times 600 \text{ ohms} =$$

$$\frac{0.755}{0.755} \times 600 = \quad 1 \times 600 =$$

$$600 \text{ ohms}$$

$$\text{Input return loss} = 20 \log_{10} \frac{Z_{in} + 600}{Z_{in} - 600}$$

(f) For the radio orderwire output impedance, connect the equipment as shown in figure 18-4, and set the oscillator for 600 ohms output impedance.

Turn the radio set off or terminate the FM subcarrier demodulator to preclude extraneous signals from affecting the test results.

(g) Repeat paragraphs 18-4a(2) (b) through (f) and record the results on figure 18-2 (USACC Form 635-R). The input and output impedances should be between 491 and 732 ohms to provide a return loss of 20 dB. The return loss can be calculated from:

$$\text{Return loss} = 20 \log_{10} \frac{Z_n + Z_\ell}{Z_n - Z_\ell}$$

Where:

Z_n = network impedance
Z_ℓ = two-wire termination impedance

(h) If the automatic method with the delay measuring set is used to determine the impedance, connect the test equipment as shown in figures 18-5 and 18-6. Record the data on figure 3-4 (DD Form 2094).

(i) Connect the equipment as shown in figure 18-6.

(j) At the transmit end, adjust the oscillator output to 0 dBm at 1 kHz and connect the oscillator output to the radio orderwire input.

(k) At the receive end, connect the frequency selective voltmeter or wave analyzer to the radio orderwire output. The frequency selective voltmeter should be in the 3.1-kHz and 600-ohm terminated positions.

(l) Maintain an input level of -7 dBm into the FM modulator as measured at J36 for each orderwire input level.

(m) For each input level to the transmit orderwire, adjust the output level control of the receive orderwire (R24) to 0 and -15 dBm.

(n) Record the results on figure 3-4 (DD Form 2094).

b. Frequency Response. This test may be performed by either an automatic or manual method. The method used will depend on the availability of test equipment and as directed by the team chief. Either method will provide satisfactory results. The test may also be performed on an RF loop or link basis.

(1) *Automatic method.*

(a) Complete the top portion of figure 3-4 (DD Form 2094).

(b) At the transmit end, calibrate the delay measuring set by connecting the 600-ohm output to a 600-ohm precision load and an AC voltmeter, as shown in figure 18-5. Allow approximately 30 minutes for the delay measuring set to stabilize.

(c) Adjust the 600-ohm output of the delay measuring set to -5 dBm at 1000 Hz.

NOTE: If the delay measuring set does not have a 600-ohm balanced output, it will be necessary to use a balanced/unbalanced transformer as shown in figure 18-5.

(d) Set the sweep frequency of the delay measuring set for a range of 200 to 3500 Hz, at a sweep rate of approximately 4 per minute. Observe the RMS or AC voltmeter as the delay measuring set sweeps across the frequency range. If the test equipment is operating properly, the voltmeter reading should not vary more than ±0.15 dB throughout the sweep range. Return the delay measuring set to the 1000-Hz setting and connect it to the radio transmit orderwire input as shown in figure 18-6.

(e) At the receive end, calibrate the delay measuring set and the X-Y recorder as shown in figure 18-5.

(f) Connect the oscillator output through the step attenuator to the balanced/unbalanced transformer (if required). Terminate the transformer secondary into the delay measuring set (set at 600 ohms) and adjust the oscillator output to -5 dBm as read on the AC voltmeter.

(g) Connect the remaining equipment as shown in figure 18-6 (receive end).

(h) Using the delay measuring set frequency counter, calibrate the X-axis of the recorder between 200 and 3500 Hz by varying the delay measuring set carrier frequency and adjusting the recorder controls for a sweep range between the frequencies.

(i) Switch the delay measuring set to the receive position and calibrate the recorder Y-axis between 0 and -10 dBm by varying the step attenuator and adjusting the logarithmic/linear amplifier and recorder controls accordingly to provide the range on the vertical axis as stated above.

(j) Once the calibration sequence has been completed, connect the receive equipment as shown in figure 18-6 with the input of the delay measuring set connected to the radio orderwire receive output terminals.

(k) At the transmit end, insert the -5 dBm 1000-Hz signal into the orderwire and, at the receive end, measure the level of the 1000-Hz signal. If the receive level is incorrect, it may be necessary to adjust the FM modulator level and the receive baseband output level controls for the proper level.

(l) At the transmit end, reduce the frequency of the delay measuring set until the receive end recorder goes off-scale, or at least to 200 Hz, or the point at which the signal is 5 dB below the 1000-Hz reference level.

(m) At the receive end, lower the recorder pen onto figure 3-4 (DD Form 2094).

(n) At the transmit end, turn on the delay measuring set sweep and allow the sweep to continue until the pen goes off-scale, or at least to 3500 Hz. Turn off the delay measuring set sweep and return the output to 1000 Hz.

(o) At the receive end, raise the pen and turn off the X-Y recorder.

(2) Manual method.

(a) At the transmit end, terminate the audio oscillator into a 600-ohm precision load and connect the RMS voltmeter across the output as shown in figure 18-6.

(b) Set the audio output to -5 dBm and slowly adjust the output frequency from 200 to 3500 Hz. Observe that the output is flat ±0.25 dB over the frequency range.

(c) At the transmit end, connect the oscillator to the radio orderwire input as shown in figure 18-6. Adjust the oscillator frequency for 1000 Hz and at an output level of -5 dBm.

(d) At the receive end, measure the level of the 1000-Hz tone with a frequency selective voltmeter or wave analyzer in the 600-ohm terminated position. If the measured level is not -5 dBm ±0.5 dB, the FM modulator and output baseband level controls should be adjusted for the proper level.

(e) At the transmit end, change the oscillator frequency to 200 Hz and, at the receive end, measure the level of the 200-Hz tone with the wave analyzer. Repeat this process for the frequencies between 200 and 3500 Hz. Record the results on figure 16-4 (DD Form 2095).

(f) If the manual method is used, plot the data from figure 16-4 (DD Form 2095) onto figure 3-4 (DD Form 2094).

c. Signal-to-Noise Flat Weighted.

(1) Connect the audio oscillator to the radio orderwire input as shown in figure 18-6. Adjust the oscillator frequency to 1000 Hz and at an output level of -5 dBm.

(2) At the receive end, measure the receive tone with the noise measuring set or wave analyzer. The received tone should be -5 dBm ±0.5 dB. If not, the radio service channel should be alined to provide the correct level.

(3) Once the correct level has been established, record this level on figure 18-2 (USACC Form 635-R).

NOTE: For this test, the radio should be configured in an RF loop with the RSL adjusted to -30 dBm. If performed on a link basis, ensure that the RSL is -30 dBm and stable.

(4) At the transmit end, insert the 100 Hz -5 dBm signal into the radio transmit orderwire. Record this level on figure 18-2 (USACC Form 635-R).

(5) At the receive end, with the noise measuring set in the flat-weighted position 600-ohm terminated, measure and record the noise on figure 18-2 (USACC Form 635-R).

(6) At the transmit end, remove the test tone and terminate the orderwire input into 600 ohms.

(7) At the receive end, measure the noise at the orderwire output with the noise measuring set, flat weighted, 600 ohms terminated. The difference in readings between tone off and tone on is the SNR in dB at a -30 RSL.

(8) Reduce the RSL to -71 dBm with the variable attenuator and repeat paragraphs 18-4c (4) through (7). Record the results on figure 18-2 (USACC Form 635-R).

d. Tone Signaling.

(1) With the radio in an RF loop or link configuration, depress the orderwire call button at the transmit end. A buzzer should sound and the call light should activate.

(2) Connect a voltmeter to the alarm remote terminals (J12, M and J) and with the voltmeter set to read resistance. Without an alarm present, the meter should read infinity. At the distant terminal, press the orderwire call button and observe that a buzzer sounds, the call light activates, and the voltmeter reads a short.

18-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheets, review the data for completeness and validity, and summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. Compare the test results to the applicable specifications in paragraph 18-2. If any test sequence fails to meet specifications, notify the responsible activity of required corrective actions.

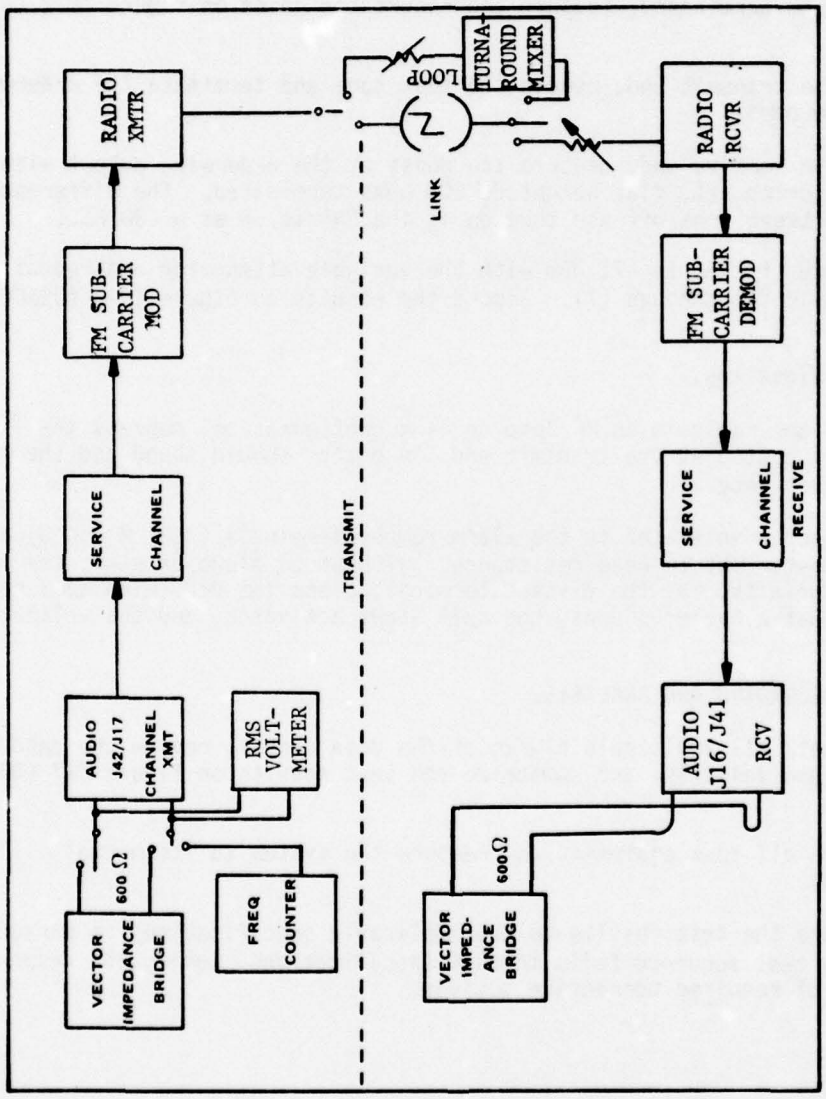


Figure 18-1. Radio orderwire characteristics (vector impedance bridge) test setup.

RADIO ORDERWIRE CHARACTERISTICS (CCR 702-1-3)

DATA SHEET

PAGE OF PAGES

DATE (MO, DAY, YEAR)

LINK NO.	XMTR NO.	RCVR NO.	RF LOOP ☐ IF LOOP ☐ LINK ☐	TEST ENGINEER
DESIGN IMPEDANCE: INPUT Ω	OUTPUT Ω	LOCAL STATION		DISTANT STATION

IMPEDANCE METHOD USED

	INPUT (XMTR)			OUTPUT (RCVR)		
FREQ (Hz)	REF LVL (dBm)	MEAS LVL (dBm)	RETURN LOSS (dB)	REF LVL (dBm)	MEAS LVL (dBm)	RETURN LOSS (dB)
350						
1500						
2000						
3000						

ORDERWIRE ADJUSTABILITY			FREQUENCY RESPONSE
XMT LVL 1000 Hz	MEAS RCV LVL	LVL DIFF (dB)	
0 dBm			300 TO 3000 Hz — IN SPEC ☐ OUT OF SPEC ☐
-5 dBm			
-10 dBm			METHOD USED
-15 dBm			

S/N - FLAT WEIGHTING — TONE

XMT FREQ Hz	RCV TONE LVL dBm	MEAS NOISE dBm	S/N dB	RSL -30 dBm	IN SPEC ☐ OUT OF SPEC ☐
	dBm	dBm	dB	RSL -71 dBm	

TONE SIGNALING

BUZZER ACTIVATED	LIGHT ACTIVATED	RELAY CONTACTS
YES ☐ NO ☐	YES ☐ NO ☐	INF YES ☐ NO ☐ SHORT YES ☐ NO ☐

COMMENTS

USACC FORM 635-R
1 MAY 79

Figure 18-2. Radio orderwire characteristics data sheet.

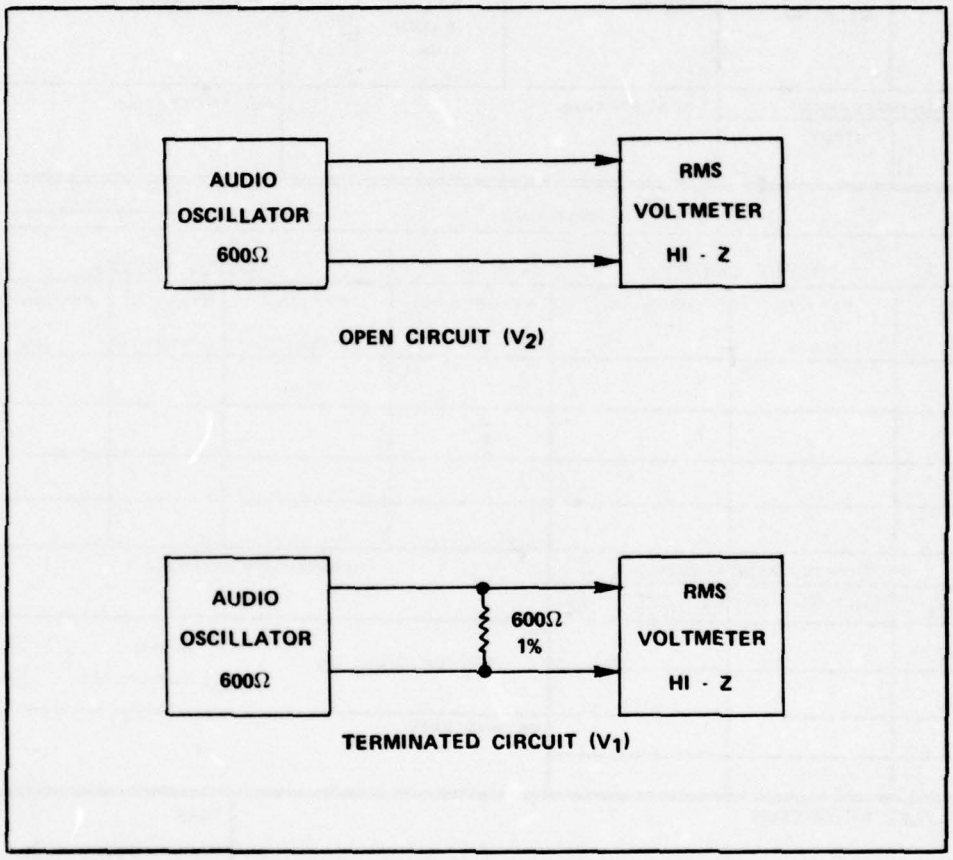


Figure 18-3. Radio orderwire impedance (comparison method, calibration) test setup.

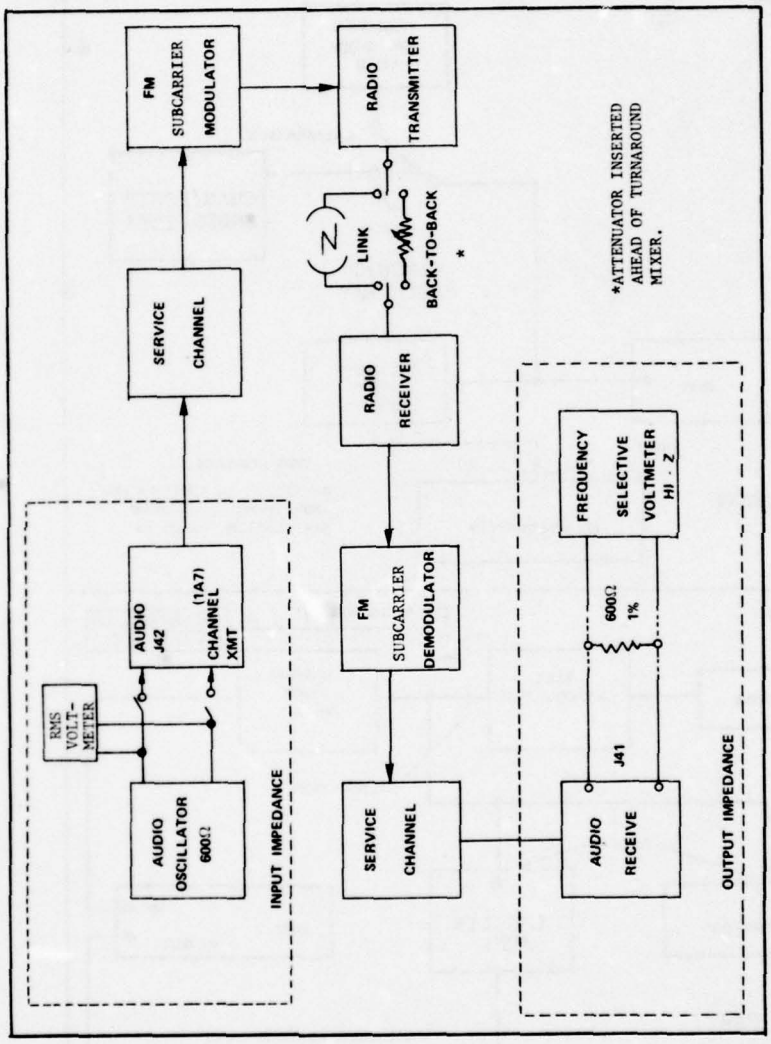


Figure 18-4. Radio orderwire impedance (comparison method) test setup.

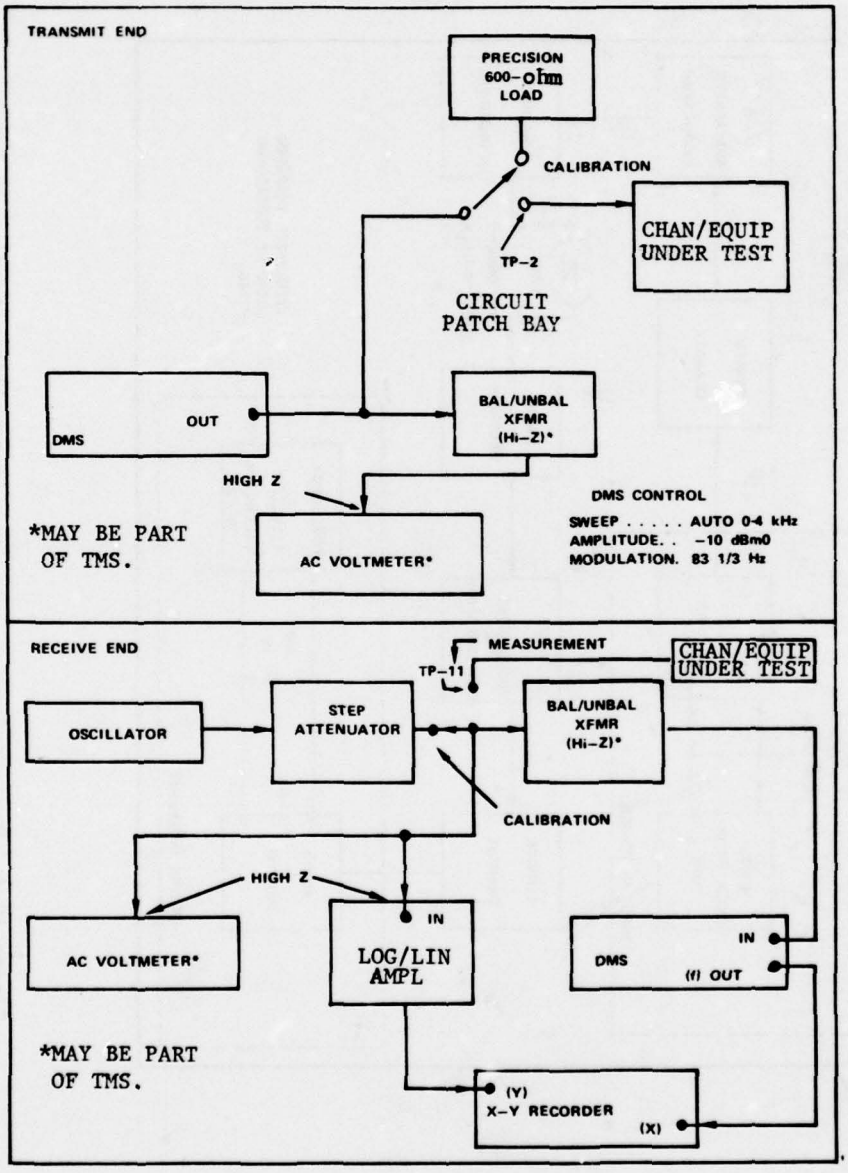


Figure 18-5. Radio orderwire impedance using DMS calibration and test setup.

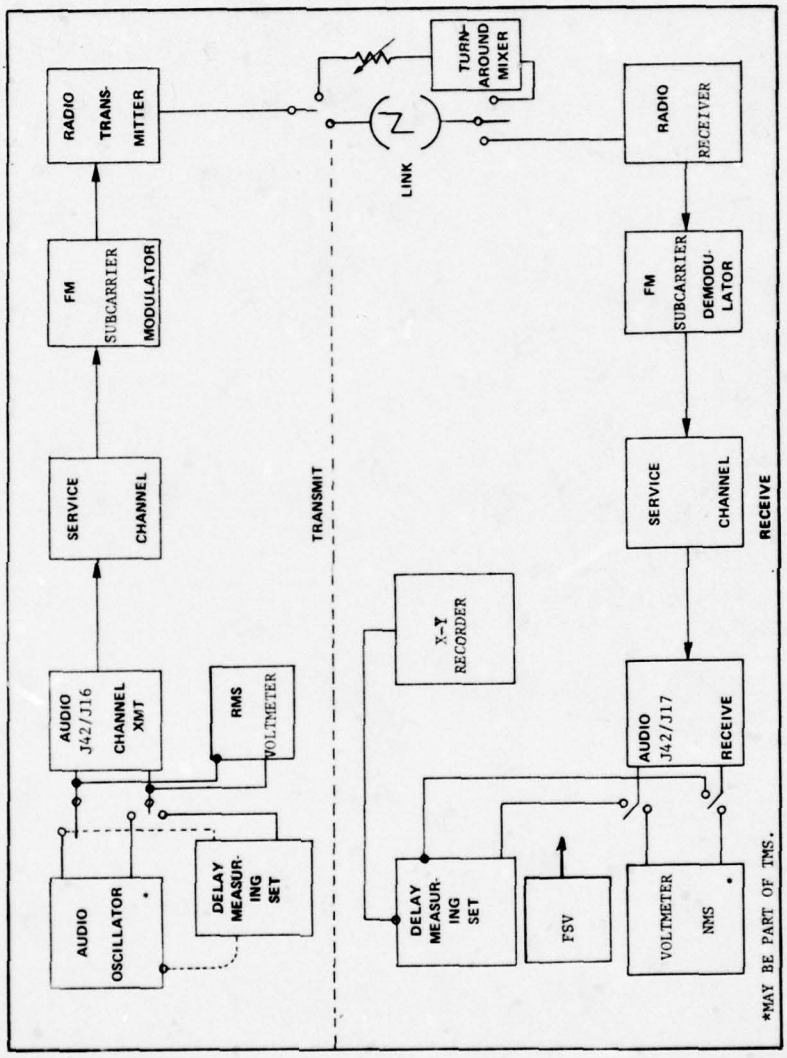


Figure 18-6. Radio orderwire impedance (automatic method) test setup.

CHAPTER 19

RADIO ORDERWIRE SUBCARRIER FREQUENCY AND STABILITY (DT-216)

19-1. GENERAL.

a. The purpose of this test is to measure the radio orderwire subcarrier frequency.

b. There are two basic methods that may be used to determine the frequency and stability of the radio orderwire subcarrier. The first is a spot measurement or a number of spot measurements under prevailing environmental conditions of humidity and temperature. These spot measurements would then be averaged to determine the accuracy over the measurement period. The second method consists of a long-term recording of the subcarrier frequency under controlled environmental conditions. This is the method that would normally be performed at a contractor's facility, while the spot method would be adequate for most field testing.

c. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

d. This test may be performed in an RF loop or on a link basis.

19-2. SPECIFICATIONS.

a. The AN/FRC-162 orderwire subcarrier frequency shall be 8.1±0.002 MHz at 25±5 degrees Centigrade. Elsewhere in the range of 0- to 50-degrees Centigrade, the frequency shall remain within 0.02 MHz of the 8.1-MHz nominal frequency. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

19-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. Digital recorder.

c. Frequency selective voltmeter.

d. Temperature probe and indicator.

19-4. TEST PROCEDURES.

a. Method 1.

(1) Connect the test equipment as shown in figure 19-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Remove all modulation from the FM subcarrier module by terminating the input to the FM subcarrier modulator.

(3) Connect the frequency counter to the RF monitor test jack as shown in figure 19-1. Connect the digital recorder to the frequency counter output. Measure the frequency for approximately 15 minutes and, from the recorder, determine the average error frequency over the measured period. Record the average frequency and computed accuracy on figure 19-2 (DD Form 2102). Modify the form as necessary to show the parameter being measured.

b. Method 2.

(1) Connect the frequency selective voltmeter and digital printer as shown in figure 19-1. If this method is used, record the average frequency and the computed accuracy of the pilot oscillator on the data sheet. Indicate in the comments section of the data sheet the method used.

(2) If the subcarrier oscillator frequency and stability are to be measured over a range of controlled environmental conditions, locate a temperature sensor on the subcarrier module as shown in figure 19-1. Connect the sensor output to the recorder and vary the temperature range of the radio set as specified in paragraph 19-2. Record the frequency accuracy, stability, and temperature range on the data sheet.

19-5. DATA RECORDING AND ANALYSIS.

a. Record measurements pertaining to the radio orderwire subcarrier in the comments section of the data sheet.

b. Review all test data for validity and compare the measured results to the applicable specifications. Summarize the test results on figure 3-7 (DD Form 2091).

c. Remove all test equipment and restore the system to its normal configuration.

d. If the radio fails to meet specifications, notify the responsible activity of required corrective actions.

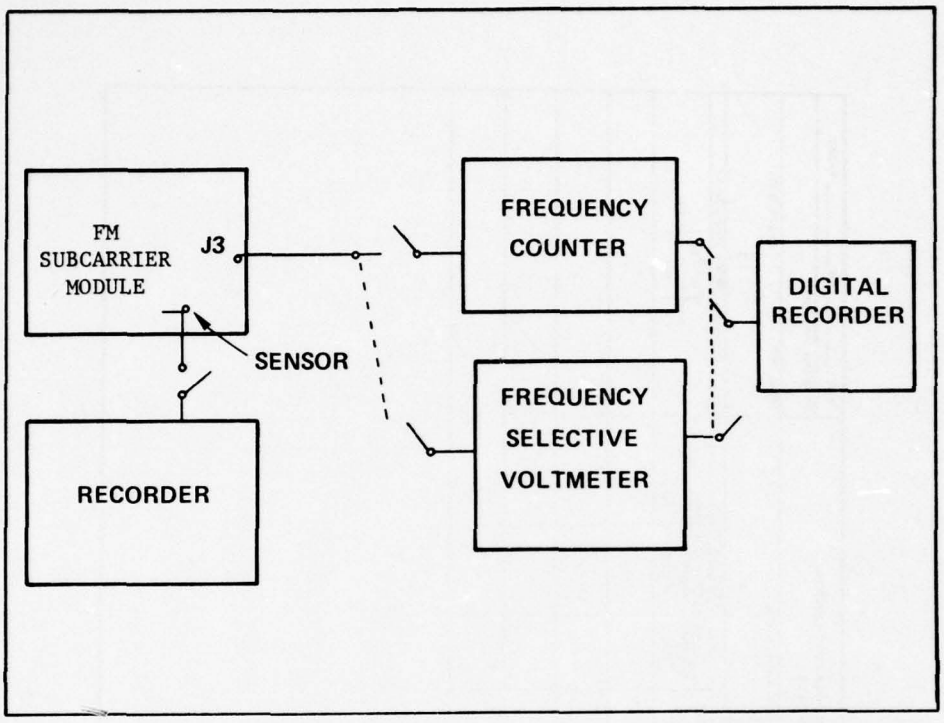


Figure 19-1. Radio orderwire subcarrier frequency accuracy test setup.

TRANSMITTER RF CARRIER/RECEIVER LOCAL OSCILLATOR
FREQUENCY ACCURACY DATA

PAGE _____ OF _____ PAGES

DATE (day, mo., year)

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

TRANSM. ☐ RECEIVER ☐	TEST RUN TIME			RADIO FREQ. (MHz)	L.O. CRYSTAL FREQ. (If Used) (MHz)	FREQUENCY				FREQEUNCY ACCURACY, %
	START	STOP	DURATION MIN.			ASSIGNED FREQ. F_O (MHz)	MEASURED FREQ. (MHz) MINIMUM F_{MIN}	MAXIMUM F_{MAX}	AVERAGE F_{AVGE}	$A = \left\| \frac{F_O - F_{ave}}{F_O} \right\| \times 100$
NO. 1										
NO. 2										
NO. 3										
NO. 4										

COMMENTS:

DD FORM 1 SEP 77 2102

Figure 19-2. Transmitter RF carrier/receiver local oscillator frequency accuracy data sheet.

CHAPTER 20

RADIO PILOT CONTINUITY AND STABILITY (DT-217)

20-1. GENERAL.

a. The purpose of this test is to measure the accuracy, stability, and indications of continuity of the radio pilot frequency.

b. There are two basic methods that may be used to determine the accuracy and stability of the radio pilot frequency. The first is a spot measurement or a number of spot measurements under prevailing environmental conditions of temperature and humidity. The second method consists of a long-term recording of the radio pilot oscillator output under controlled environmental conditions. This is the method that would normally be performed at a contractor's facility, while the spot method would be adequate for most field testing.

c. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel as directed.

20-2. SPECIFICATIONS.

a. The AN/FRC-162 radio shall insert a pilot tone signal (8.5 MHz) into the baseband of each transmitter and monitor the signal continuity. The pilot tone shall be detected in the output of each receiver and monitored for any decrease below a preset adjustable level. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

20-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. Digital recorder.

c. Frequency selective voltmeter.

d. RF attenuators.

e. Turnaround mixer.

20-4. TEST PROCEDURES.

a. Radio Pilot Level, Frequency, and Stabiity.

(1) Connect the equipment as shown in figure 20-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Connect the frequency selective voltmeter to the pilot oscillator output (J1-A) and verify that the pilot level is -70 dBm. If the level is incorrect, adjust the pilot oscillator output control for the proper level. Verify that the level at J-25 (pilot detector) is -40 dBm.

NOTE: The frequency selective voltmeter should be set to 8.5 MHz and to the 250-Hz bandwidth position.

(3) Once the level has been verified, connect the frequency counter and digital recorder, or the frequency selective voltmeter and digital recorder, to the pilot oscillator output.

(4) Record the frequency of the pilot oscillator for approximately 15 minutes and average the error deviation for the recorded period. Record the average frequency error on figure 19-2 (DD Form 2102) and compute the accuracy of the pilot oscillator as shown on the data sheet. Modify the form as necessary to show the parameter being measured.

(5) If this test is to be performed in conjunction with and in correlation with temperature variations, connect a temperature sensor probe at the pilot oscillator assembly. Record the temperature at which the frequency stability was determined.

(6) If the sensor will not directly drive the recorder, connect the sensor to a frequency counter. The output of the counter would then be connected to a digital printer.

b. Radio Pilot Continuity and Alarm.

(1) Connect the frequency selective voltmeter to J58-A as shown in figure 20-1.

(2) With the transmitter pilot at the normal level, measure and record the pilot level in the comments section of the data sheet.

(3) At the transmitter, adjust the pilot oscillator control until the pilot level has been reduced by 3 dB, and observe that a pilot alarm is indicated at the transmitter. Record whether an alarm was observed in the comments section of the data sheet.

(4) At the transmitter, adjust the pilot oscillator output until the level is 6 dB down from the normal level.

(5) At the receiver, measure the level with the frequency selective voltmeter and observe that the receiver indicates loss of pilot tone. Record the results in the comments section of the data sheet.

20-5. DATA RECORDING AND ANALYSIS.

a. Record all test results on the data sheet and compare the test results with the applicable specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet the applicable specifications, notify the responsible activity of required corrective actions.

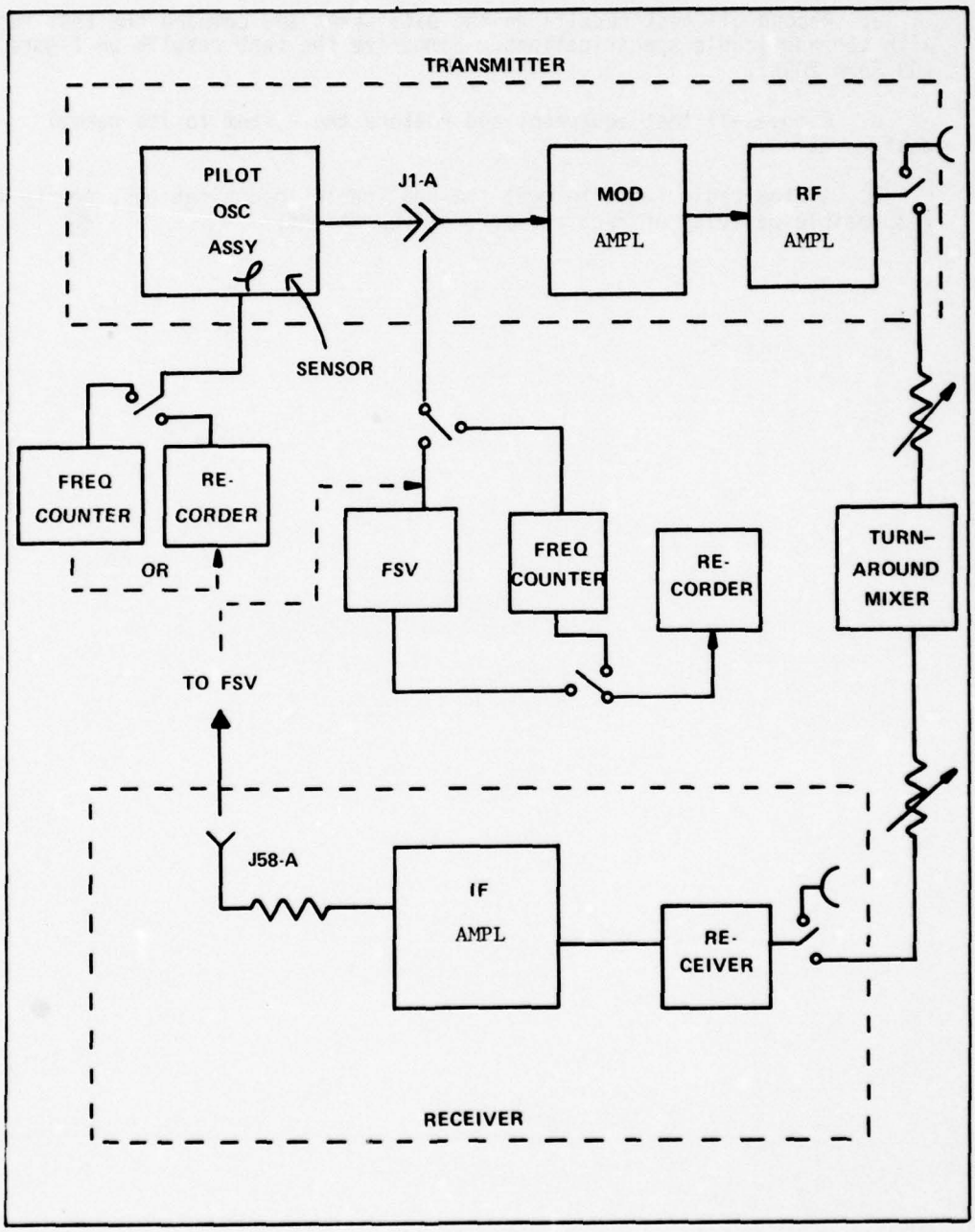


Figure 20-1. Radio pilot, continuity, and stability test setup.

CHAPTER 21

RECEIVER BASEBAND LINEARITY AND GROUP DELAY (DT-218)

21-1. GENERAL.

a. The purpose of this test is to measure the linearity and delay from the receiver RF and IF inputs to the baseband output.

b. This test may be performed as part of an alinement procedure or as a final verification of total receiver performance. The team chief will determine whether or not the test is to be performed.

c. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel as directed.

21-2. SPECIFICATIONS. The radio shall operate as specified in the standard engineering plan or contract specifications.

21-3. TEST EQUIPMENT REQUIRED.

a. RF sweep generator.

b. Microwave link analyzer.

c. Power meter.

d. Frequency counter.

e. Wideband amplifier (if required).

f. Oscilloscope camera.

21-4. TEST PROCEDURES.

a. RF Input to Baseband Linearity.

(1) Perform a microwave link analyzer back-to-back calibration and checkout as stated in the manufacturer's manual.

(2) Set the RF sweep generator to the CW mode and connect the frequency counter to the generator output. Adjust the RF sweep generator to the exact frequency of the receiver under test.

(3) Set the power output of the RF sweep generator to provide a -30 dBm signal input to the receiver at the RF interface point.

(4) With the frequency counter (fig. 21-1a, calibration) set the sweep width output of the generator to cover the desired RF/IF bandwidth. For this procedure, a bandwidth of 10 MHz will be used for illustration purposes.

(5) Connect the generator RF output to the receiver RF test port or input waveguide as shown in figure 21-1b after the calibration sequence has been completed.

(6) Connect the microwave link analyzer transmitter to the RF sweep generator as shown in figure 21-1b and allow approximately 30 minutes for warmup and stabilization. The connections are on the rear apron of the generator.

(7) Set the microwave link analyzer controls as follows:

(a) Baseband power level to -30 dBm.

(b) Sweep calibration to fully counterclockwise.

(c) Sweep vernier to fully clockwise.

(d) Receiver sweep source to external baseband.

(e) Sweep width to 10 MHz.

(f) Baseband input to external 75 ohms.

(g) Baseband frequency (receiver and transmitter) to 500 kHz (or 555 kHz depending on option).

(h) Y1 to IF.

(i) Y2 to delay.

(j) Markers to ±5 MHz.

(8) Connect the receiver IF monitor jack output to the IF input (70 MHz) of the microwave link analyzer receiver. Adjust the microwave link analyzer receiver internal IF attenuator for an on-scale reading of the IF level meter. If there is insufficient gain from the IF monitor test point to provide a full-scale reading, a wideband amplifier may be used as shown in figure 21-1b. If an amplifier is used, the linearity, amplitude response, and gain should be verified before proceeding with the test. Verify that the microwave link analyzer AFC lock light is on and the IF uncalibrated light is extinguished.

(9) Turn the microwave link analyzer sweep calibrate control slowly clockwise until the markers just reach the edge of the trace as shown in figure 21-2. The sweep output level control may have to be increased slightly by slowly turning the control clockwise to obtain a stable, clear trace.

(10) Turn the blanking control off and adjust the X-phase shift control until the forward and return traces are superimposed on the CRT. Turn the blanking control on.

(11) Set the Y1 display to baseband and adjust the baseband input level control to give an on-scale reading on the microwave link analyzer's baseband level meter. Calibrate the Y1 (baseband linearity) trace using the Y1-Y2 calibration switch set to the appropriate percent (usually 1 percent per division) and adjust the Y1 gain to set the separation between the double Y1 trace to one division. The Y1 trace is now calibrated for baseband linearity. Turn the Y1-Y2 calibration switch off.

(12) Calibrate the Y2 trace for delay as follows:

(a) Adjust the set level control to fully clockwise and adjust the phase-lock for an up-scale deflection of the phase-lock/level meter.

(b) Readjust the set level control for a reading in the green band of the phase-lock/level meter.

(c) Adjust the phase-lock control for a peak on the phase-lock/level meter, and if necessary, readjust the set level for the green band.

(d) Set the difference phase calibrate switch to the appropriate nsec per division value and adjust the Y2 gain control for a one-division separation of the double Y2 trace.

(e) Turn the difference phase calibrate switch off.

(f) The Y2 trace is now calibrated.

(13) Photograph the microwave link analyzer traces and mount the photographs on figure 5-2 (DD Form 2093). Ensure that all pertinent calibration and measurement data are annotated on the data sheet. As a minimum the following should be entered to identify each photograph.

(a) Linearity.

(b) Delay slope.

(c) Delay parabolic.

Modify the data sheet as necessary, and if additional space is required, use figure 3-7 (DD Form 2091).

b. Input to Baseband Linearity.

(1) Perform a microwave link analyzer back-to-back calibration and checkout as stated in the manufacturer's manual. For calibration see figure 21-1a.

(2) Connect the test equipment as shown in figure 21-3 and allow approximately 30 minutes for warmup and stabilization.

(3) Set the microwave link analyzer switches and controls as follows:

(a) Sweep to internal.

(b) Sweep width to 10 MHz.

(c) Deviation to 140 kHz RMS.

(d) Baseband frequency to 500 kHz on the transmitter and receiver.

(e) IF to 70 MHz.

(f) Baseband input to external 75 ohms.

(g) Sweep source to internal IF.

(h) Blanking to off.

(i) Y1 to IF.

(j) Y2 to delay.

(k) Markers to ±5 MHz.

(4) Connect the receiver IF monitor jack to the microwave link analyzer IF input as shown in figure 21-3. Adjust the microwave link analyzer IF attenuator for an on-scale reading on the IF level meter. If there is insufficient gain from the IF, use a wideband amplifier. If an amplifier is used, verify the characteristics of the amplifier before proceeding with the test. Verify that the AFC lock light is on and the IF uncalibrated light is off.

(5) Adjust the X-phase shift control to superimpose the forward and return traces and turn the blanking switch on.

(6) Set the Y1 display to baseband and adjust the baseband level control to give an on-scale reading on the baseband level meter. Calibrate the Y1 trace as in paragraph 21-4a(11). The delay response for IF to baseband may differ from that of RF to baseband because of the link delay equalizer network which is part of the IF input sequence.

(7) Perform the equipment alinement adjustments as specified in the equipment technical manual to provide best receiver performance.

(8) Photograph the delay and linearity response curves and mount the photographs on figure 5-2 (DD Form 2093). Modify the form as necessary as outlined in paragraph 20-4(13). An example of a delay and linearity trace is shown in figure 21-2.

21-5. DATA RECORDING AND ANALYSIS.

a. Review all test data for validity and compare the test results with the applicable specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

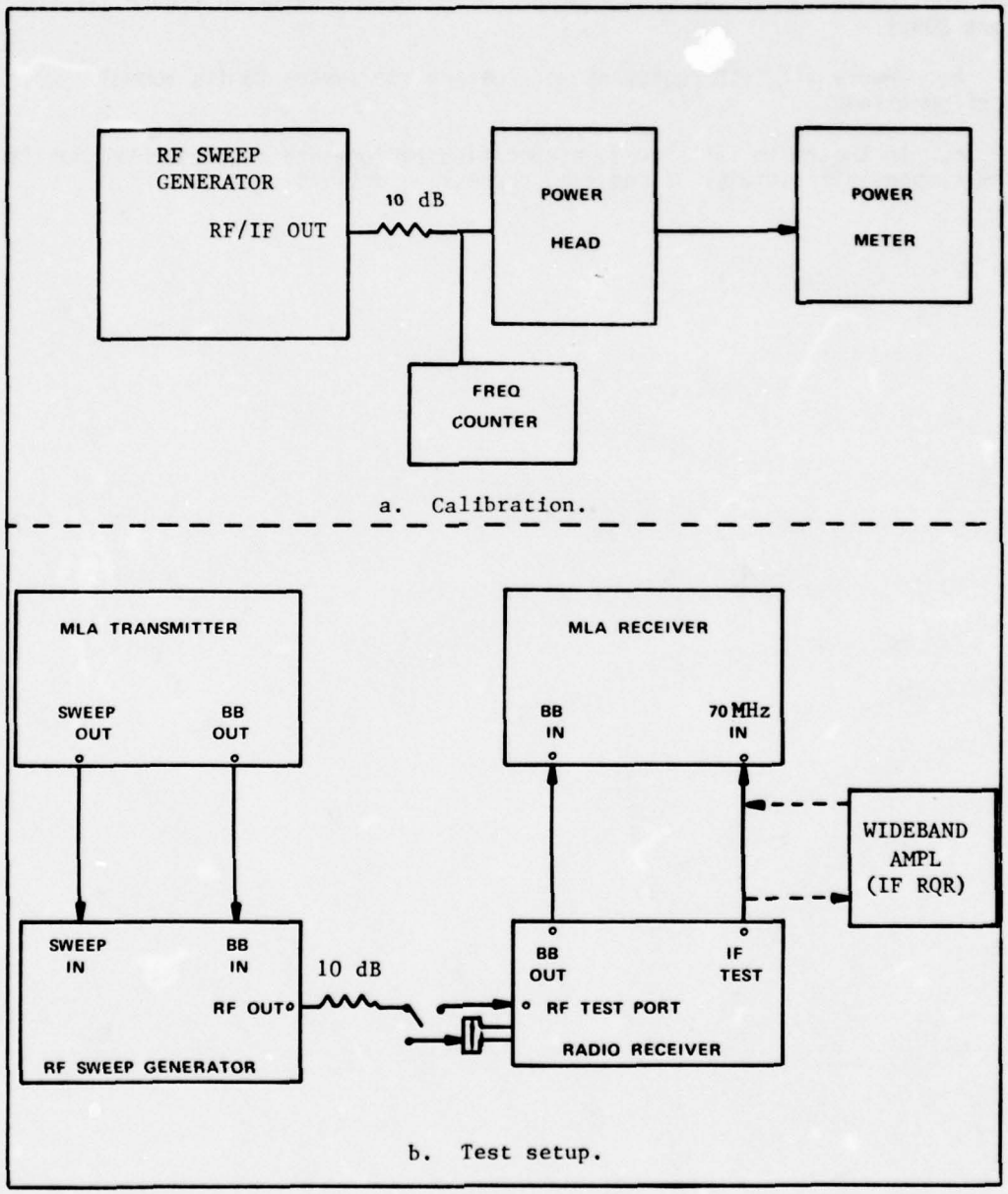
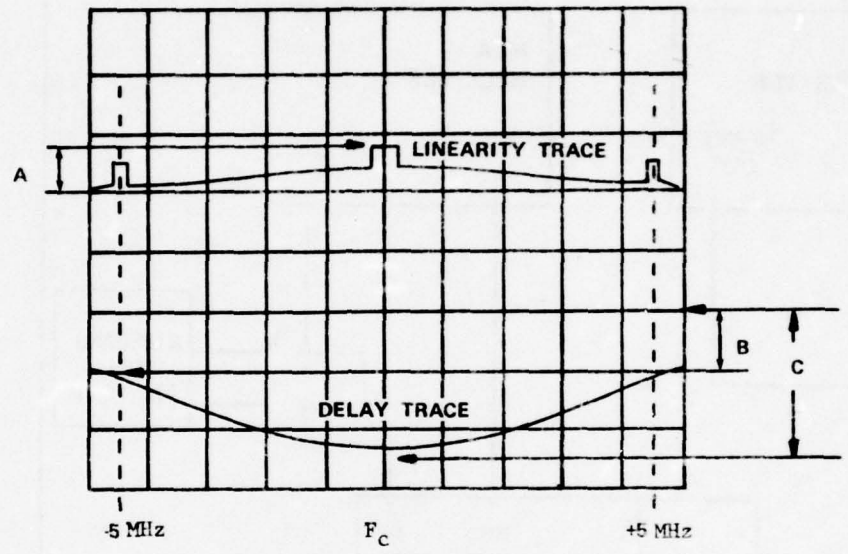


Figure 21-1. Receiver baseband linearity and group delay (RF to baseband) calibration and test setup.



LINEARITY SCALE = 1% PER DIV
DELAY SCALE = 1 nsec PER DIV
MARKERS = ±5 MHz FROM F_C

A = 0.6 DIV @ 1% PER DIV = 0.6% NONLINEAR OF 99.4% LINEAR
B = 0.9 DIV @ 1 nsec/DIV = 0.9 nsec DELAY SLOPE
C = 2.1 DIV @ 1 nsec/DIV = 2.1 nsec DELAY PARABOLIC

Figure 21-2. Typical linearity and delay response curve, microwave link analyzer presentation.

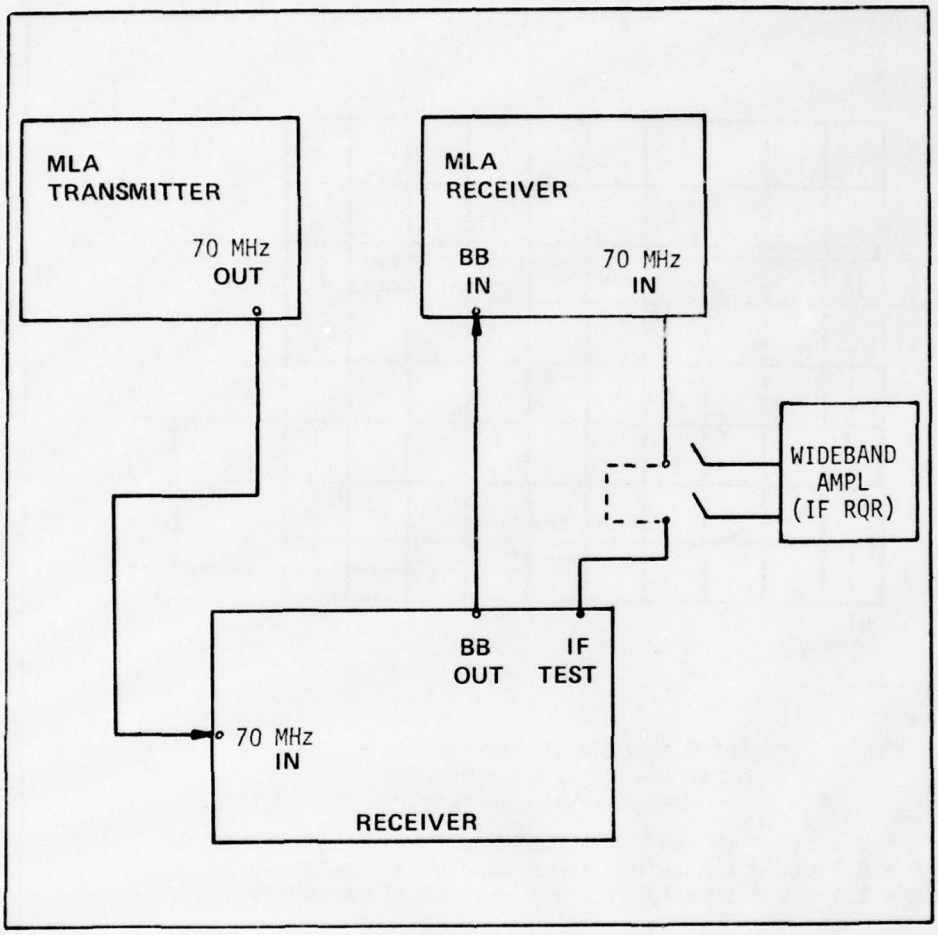


Figure 21-3. Typical receiver baseband linearity and group delay (IF to baseband) test setup.

CHAPTER 22

LINK BASEBAND LINEARITY AND GROUP DELAY (DT-219)

22-1. GENERAL.

a. The purpose of this test is to measure the linearity and group delay response from baseband-to-baseband on a link basis.

b. This test may be used to optimize the radio transmitter and receiver performance on a link basis after all other corrective adjustments and maintenance have been accomplished.

c. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite testing as directed.

22-2. SPECIFICATIONS.

a. On a single loop basis, the delay should be no greater than 6 nsec parabolic (bulge) and 1 nsec slope at ±5 MHz. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

22-3. TEST EQUIPMENT REQUIRED.

a. Microwave link analyzer.

b. Wideband amplifier (if required).

c. Delay and linearity signal analyzer.

d. Delay and linearity test generator.

e. Voltmeter.

f. Oscilloscope.

g. Adapters and cables as required.

22-4. TEST PROCEDURES. Although two methods are described for measuring the linearity and delay, they are essentially the same except for selection of the test equipment.

a. Microwave Link Analyzer (fig. 22-1). Before performing this test, the baseband levels should be verified as correct and all required maintenance accomplished on the individual radio transmitters and receivers.

(1) At the transmit and receive ends of the link, perform a back-to-back calibration and checkout of the microwave link analyzer in accordance with the manufacturer's manual.

(2) At the receive end of the radio link, set the microwave link analyzer controls as follows:

(a) Baseband input to external 75 ohms.

(b) Sweep source to external baseband.

(c) Blanking to on.

(d) Y1 to IF.

(e) Y2 to delay.

(f) Markers to ±5 MHz.

(g) Baseband frequency to 500 or 555 kHz.

(3) At the transmit end of the radio link, set the microwave link analyzer controls as follows:

(a) Sweep calibrate to fully counterclockwise.

(b) Sweep to internal.

(c) Sweep width to 10 MHz.

(d) Baseband power to -37 dBm (for AN/FRC-162 radio).

(e) Baseband frequency to same as that used at the receive end.

(4) At the transmit end, connect the microwave link analyzer baseband output plus sweep to the transmitter baseband input at a -37 dBm level. Allow approximately 30 minutes for warmup and stabilization. This level will be different for other types of radios; therefore, the specific level for the type radio under test should be determined before proceeding with the test.

(5) At the receive end of the radio link, connect the receiver baseband output to the microwave link analyzer baseband input terminals as shown in figure 22-1. Connect the receiver IF test point to the 70-MHz IF input of the microwave link analyzer. Adjust the microwave link analyzer IF attenuator for an on-scale reading on the IF level meter. If there is insufficient gain at the IF test point, use a wideband amplifier as shown in figure 22-1. If an amplifier is used, determine its characteristics before proceeding with the test.

(6) At the receive end, verify that the microwave link analyzer AFC lock light is on and the IF uncalibrated light is off.

(7) At the transmit end, slowly turn the microwave link analyzer sweep calibration control clockwise until the markers are positioned at the outer edge of the CRT trace. Refer to figure 21-2.

NOTE: For IF bandwidths other than 10 MHz, adjust the microwave link analyzer sweep markers and baseband frequency controls accordingly.

(8) At the receive end, set the microwave link analyzer Y1 display to baseband and adjust the baseband level control to provide an on-scale reading on the baseband level meter. Calibrate the trace using the Y1-Y2 calibration switch to set the appropriate percent per division setting (usually 1 percent). Adjust the Y1 gain control to set the separation of the double Y1 trace to one division as observed on the CRT. The Y1 delay trace is now calibrated for baseband linearity. Turn the Y1-Y2 calibration switch off.

(9) At the receive end, calibrate the microwave link analyzer Y2 delay trace. Adjust the set level control to the fully clockwise position and adjust the phase-lock for an up-scale deflection as read on the phase-lock/level meter. Readjust the set level control for a reading in the green band as displayed on the phase-lock/level meter. Adjust the phase-lock control for a peak on the phase-lock/level meter, and if necessary readjust the set level control for a green band reading. Set the differential phase calibration switch to the appropriate nsec per division value and adjust the Y2 gain control for one-division separation of the double Y2 trace. Turn the differential phase calibrate switch off. Y2 should now be calibrated for group delay.

(10) Adjust the radio transmitter and receiver modules as necessary for best link performance.

(11) Photograph the final link baseband delay and linearity and mount the photographs on figure 5-2 (DD Form 2093). Modify the form as necessary to reflect the following information.

(a) Linearity.

(b) Delay slope.

(c) Delay parabolic.

If additional space is required, use figure 3-7 (DD Form 2091).

NOTE: An example of a delay and linearity CRT trace is shown in figure 21-2.

(12) Repeat the above procedures for each transmitter-receiver combination. Reverse the transmit and receive roles and repeat the entire procedure.

(13) Remove all test equipment and restore the system to its normal configuration.

b. Delay and Linearity Test Set.

(1) At the transmit end, disconnect the transmit baseband input to both transmitters and terminate the cables into 75 ohms.

(2) Connect the transmit test equipment as shown in figure 22-2, with the linearity test generator connected to the transmit baseband input (J1) of the radio under test.

(3) On the linearity test generator, turn the sweep signal switch off and set the signal level control for a -37 dB indication on the voltmeter for the AN/FRC-162. Different radios may require other levels.

(4) On the linearity test generator, turn the sweep signal switch on and adjust the sweep signal level control for -15 dB as read on the voltmeter.

(5) At the receive end, connect the equipment to the companion receiver under test (fig. 22-2).

(6) Set the linearity analyzer mode switch to 10 nsec delay and the input attenuator switch to 10 dB. Adjust the oscilloscope controls and the linearity analyzer horizontal control for an oscilloscope display of two horizontal traces that are 5 vertical divisions apart and 10 horizontal divisions wide. This calibrates the oscilloscope for 2 nsec per vertical division and 1 MHz per horizontal division. The delay can now be read directly on the oscilloscope. Typical delay characteristics are shown in figure 22-3.

(7) Photograph the oscilloscope presentation and mount the photographs on figure 5-2 (DD Form 2093). Modify the form as necessary to provide the data outlined in paragraph 22-4b(1).

(8) If the equipment must be equalized for link operation, adjust the equipment equalizers for best performance as outlined in the equipment technical manual.

(9) Repeat the above procedures for each transmitter-receiver combination. Reverse the transmit and receive roles and repeat the entire procedure.

22-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for validity and conformance to the applicable specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified performance, notify the responsible activity of required corrective actions.

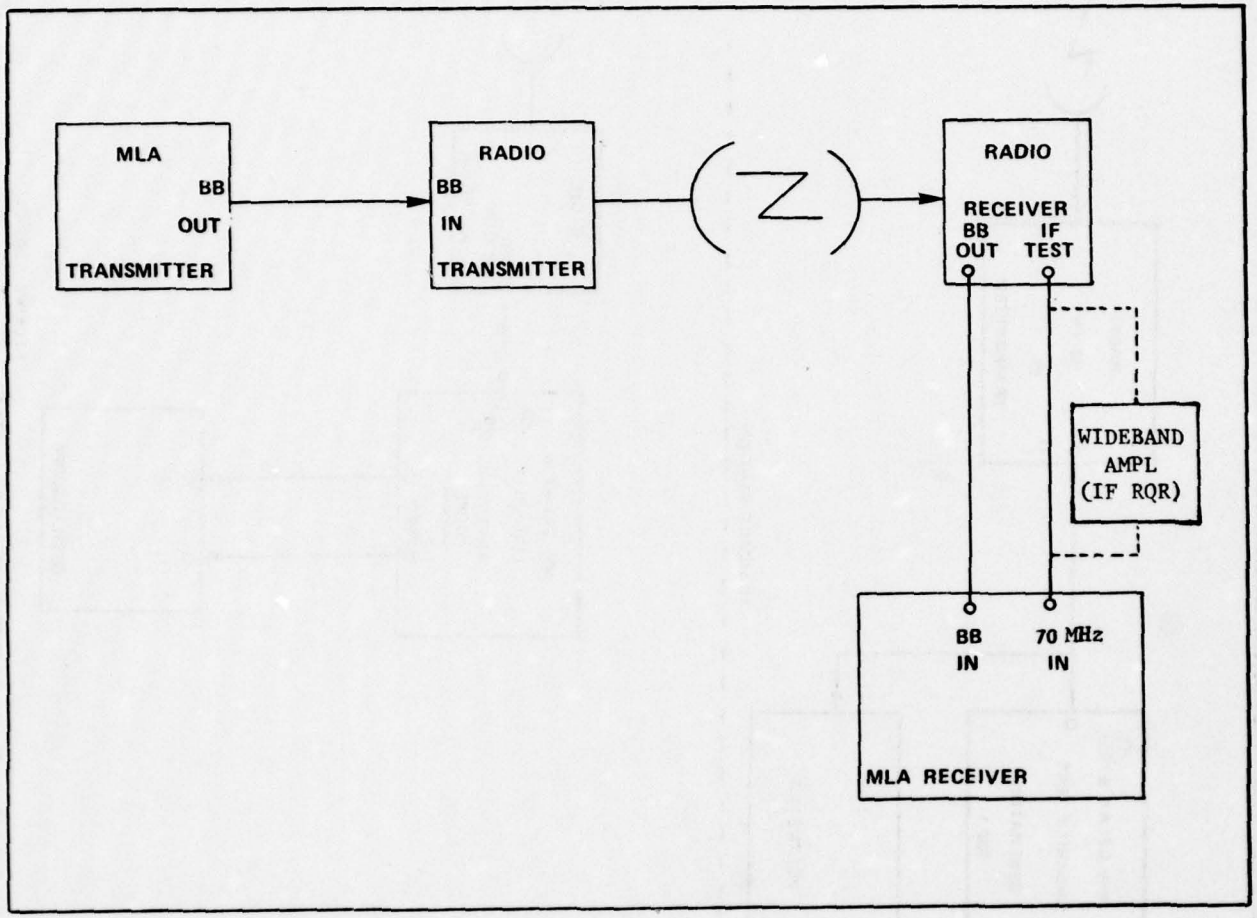


Figure 22-1. Link baseband linearity and group delay test setup.

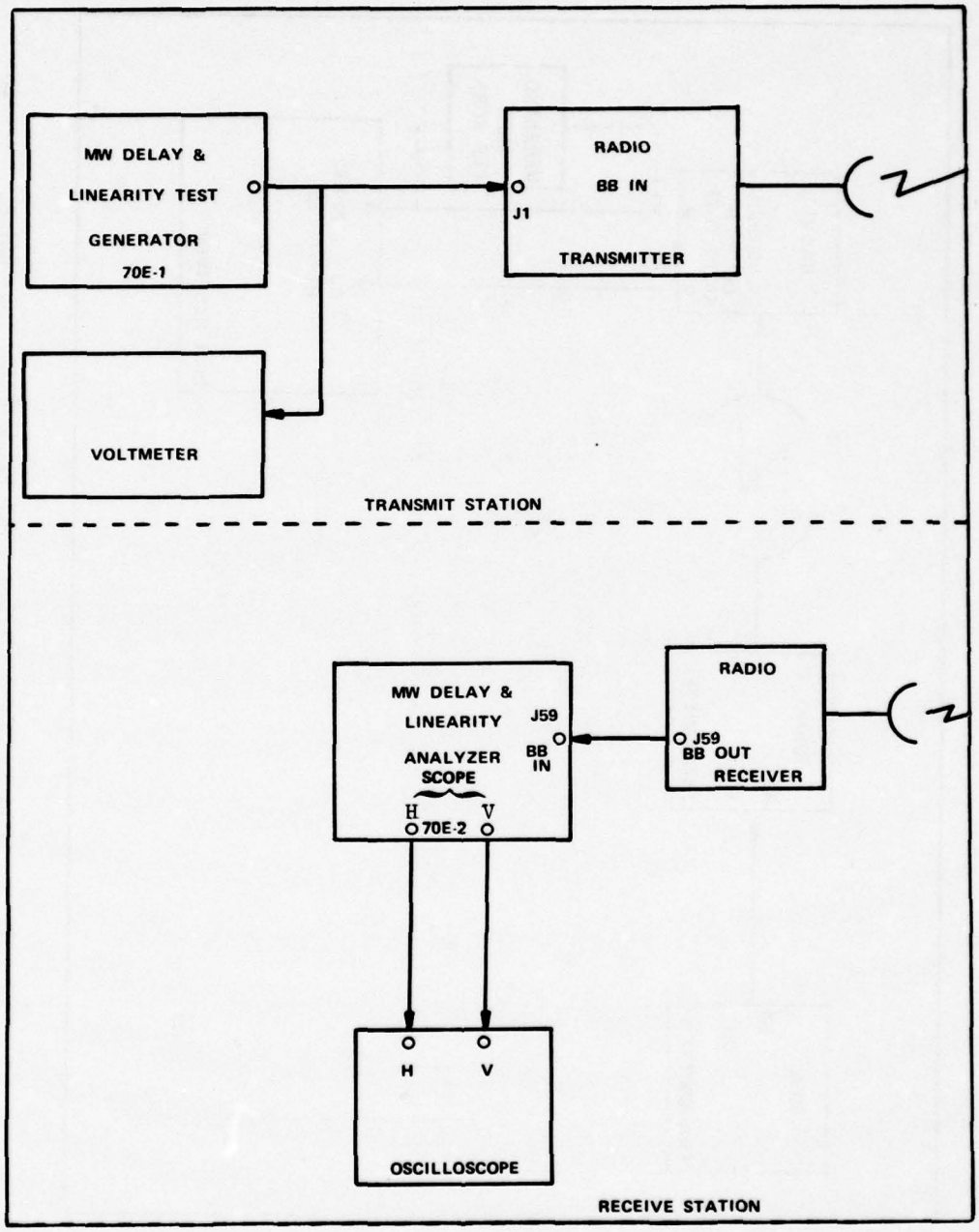
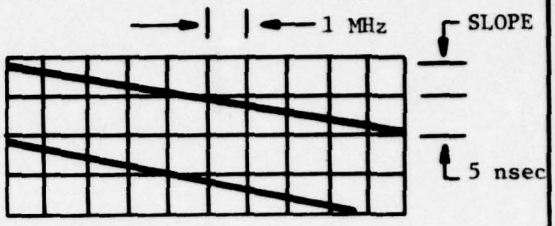
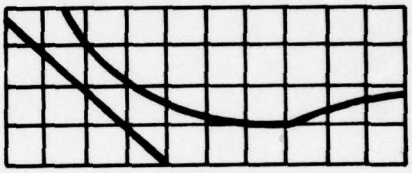


Figure 22-2. Radio baseband delay and linearity, using a delay and linearity test set, test setup.

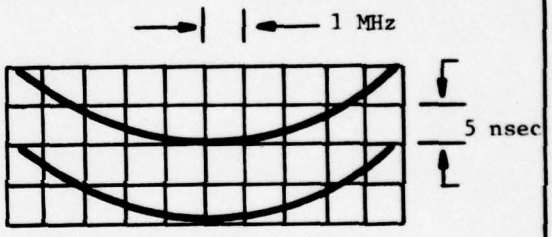
A. EXAMPLE OF SLOPE @ 8 nsec SLOPE OVER ±5 MHz BW.



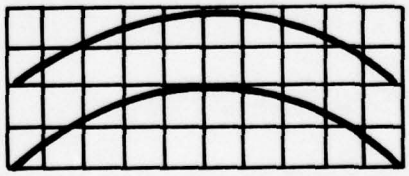
B. EXAMPLE OF EXCESSIVE DELAY ON UNEQUALIZED HOP.



C. TYPICAL NATURAL DELAY UNEQUALIZED HOP WITH 25 MHz IF 2 nsec OF SLOPE AND 8 nsec OF BULGE FOR ±5 MHz BW.



D. EXAMPLE OF OVEREQUALIZING SHOWING POSITIVE BULGE.



E. TYPICAL EQUALIZED DELAY ON ONE HOP WITH 25 MHz IF LESS THAN 1 nsec OF SLOPE OR BULGE FOR ±5 MHz BW.

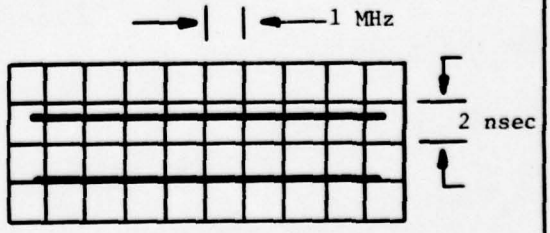


Figure 22-3. Typical delay characteristics.

CHAPTER 23

TRANSMIT RF AND RECEIVE BASEBAND SPURIOUS EMISSIONS, AND RECEIVE RADIO INTERFERENCE (DT-220)

23-1. GENERAL.

a. The purpose of this test is to:

(1) Examine the transmit and receive baseband spectrum for spurious emissions with the radio set intraffic.

(2) Measure and record any spurious emissions at the transmit RF interface point and at the receive baseband with the transmitter input terminated.

(3) Measure and record any spurious emissions at the transmitter RF interface point, the receive IF, and the baseband with the transmitter modulator input loaded with white noise or 12.6 mb/s data.

(4) Examine the transmitter RF and receiver spectrum with the multiplex terminated.

(5) Measure and record any radio interfering signals at the receive RF interface point, the IF, and the baseband output.

b. Spurious emissions can originate at almost any point within a radio transmitter or receiver due to overexcitation, intermodulation products, harmonics from local oscillators, etc. This test can be used to isolate a particular spurious emission originating within instation equipment or over a radio link on a system basis. The effect that a spurious emission may have on system performance depends on the level, frequency, and relationship of the spurious emission to the traffic the system may support.

c. The test data for the frequency spectrum evaluation consists of frequency spectrum analyzer photographs for the different test sequences. All RF and IF spectrum photographs will be mounted on figure 5-2 (DD Form 2093). All test sequences and corresponding photographs must be clearly identified with all pertinent data.

d. Each of the individual test sequences, outlined in paragraph 23-4, can be performed in an RF loop or link configuration. The method to be used will be at the discretion of the team chief.

e. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite testing as directed.

f. The frequency spectrum analysis data summary (fig. 23-1 (USACC Form 533-R)) may be modified as required to compensate for differences in

test sequences. If additional space is required for data recording, use figure 3-7 (DD Form 2091).

g. The procedures outlined in paragraphs 23-4 a through e will be performed in both directions of transmission.

23-2. SPECIFICATIONS.

a. Equipment design parameters for electromagnetic radiation shall be as specified in MIL-STD-461A.

b. With the message baseband fully loaded with traffic, radiation outside the specified bandwidth shall be better than -50 dBm. (DCAC 310-70-57, supplement 1)

c. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) With the baseband unloaded and terminated in its characteristic impedance, the radiation outside a 2-MHz band, centered at the RF carrier frequency, shall be less than -50 dBm.

(2) The second and higher harmonics of the carrier shall, under any modulation condition, be less than -30 dBm.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

23-3. TEST EQUIPMENT REQUIRED.

a. Frequency selective voltmeter.

b. Spectrum display unit.

c. RF/AF oscillator.

d. Spectrum analyzer.

e. Directional coupler.

f. Dummy load.

g. Turnaround mixer.

h. Digital multiplex.

i. Pattern generator.

j. Oscilloscope camera.

k. Attenuators, connectors, and cables, as required.

23-4. TEST PROCEDURES. The instation tests will be run with one transmitter looped back into each receiver separately. The second transmitter will be looped with only one of the receivers, unless test results indicate further testing is required.

a. Transmit and Receive Baseband Spectrum Analysis with the Radio Set Intraffic.

(1) Connect the test equipment as shown in figure 23-2, test condition (1), with the transmitter and receiver connected to the antenna system. Allow approximately 30 minutes for warmup and stabilization.

(2) At the transmit end, examine the baseband spectrum input with the frequency selective voltmeter and display unit or the spectrum analyzer as appropriate. The examinations should include at least ±5 MHz each side of the baseband input signal spectrum.

(3) With the spectrum analyzer, examine the spectrum (±10 MHz of the spectrum bandwidth) at the transmit IF and RF outputs.

(4) At the receive end, examine the baseband output with the frequency selective voltmeter and display unit or the spectrum analyzer as appropriate.

(5) At the transmit and receive ends of the link, photograph and record any spurious emissions outside the spectrum bandwidth.

b. Radio Transmitter Input Terminated.

(1) Terminate the transmitter modulator input (J24) into its characteristic impedance (75 ohms) as shown in test condition (3) of figure 23-2.

(2) With the spectrum analyzer connected to the transmitter IF interface, measure and photograph any spurious emissions above -50 dBm. The analyzer dispersal control should initially be set for at least a 20-MHz spread each side of the assigned carrier frequency.

(3) Connect the spectrum analyzer to the transmitter RF interface point as shown in figure 23-2. Ensure that adequate attenuation is inserted ahead of the analyzer to preclude overload and possible damage.

(4) Tune the spectrum analyzer to the exact transmit frequency and amplitude of any spurious emissions outside a 2-MHz band, centered at the RF carrier frequency. All emissions outside the 2-MHz band should be less than -50 dBm.

(5) Change the dispersion control of the analyzer to examine the RF spectrum at least ±10 MHz each side of the RF carrier frequency. Measure the frequency and amplitude of any spurious emissions and photographically record the results.

NOTE: Some spectrum analyzers may introduce what appears to be spurious signals if the gain is improperly adjusted. In all cases, ensure that any spurious emissions noted are not caused by the test equipment.

(6) Tune the spectrum analyzer to the 2d and 3d harmonics of the RF carrier frequency and observe any spurious signals. If any signal exceeds -30 dBm, photograph and record the results on figures 5-2 (DD Form 2093) and 23-1 (USACC Form 533-R).

(7) Remove the dummy load and connect the transmitter and receiver into an RF loop as shown in figure 23-2. If the transmitter is tuned to the exact frequency of the receiver, the turnaround mixer may be omitted.

(8) With the RF attenuators, adjust the RSL to -25 dBm, as measured at the AGC test point.

(9) At the receive end, with the spectrum analyzer, measure and record any spurious emissions noted at the receive RF and IF interface points. If spurious emissions are noted, reduce the RSL by 10 dB and check for spurious emissions again. If spurious emissions are noted with the transmitter terminated as in paragraphs 23-4f (1) through (6), unwanted mixing may be occurring in the receiver. If so, change to a known good receiver and repeat the test.

(10) At the receive end, examine the baseband output (J2) with the frequency selective voltmeter and spectrum display unit. If any extraneous signals are noted, terminate the RF receiver input to determine if the spurious signals are originating within the receiving equipment.

(11) If the test is to be performed on a link basis, remove the RF loop and connect the transmitter and receiver to the antennas. Repeat paragraph 23-4b and photograph any spurious emissions exceeding specifications.

c. Transmitter Input Baseband Fully Loaded. This test may be performed on a link basis by connecting the equipment to the antenna system as shown in figure 23-2. The link test should only be performed after all transmitting and receiving equipment has been tested and verified as being within specifications.

(1) At the transmit end, connect the digital multiplex, a white noise generator, or a 12.6-mb/s test generator to the message baseband input (J24) as shown in test condition (2), figure 23-2. If using a white noise generator to load the AN/FRC-162, the input to the transmit modulator should be at the TLP for an FM radio.

(2) Connect the transmitter output into a dummy load as shown in figure 23-2.

(3) Adjust the transmit baseband input level for 1 VPP (+2.2 dBm) as measured at J49.

(4) Connect an audio oscillator to the supervisory channel input (J15) and adjust the oscillator frequency to 4 kHz at a level of -10 dBm.

(5) Adjust the spectrum analyzer controls to display a frequency spectrum at least twice the RF carrier bandwidth when the transmitter is fully loaded.

(6) Measure and photograph any spurious emissions observed at the transmitter IF and RF interface points.

(7) Adjust the spectrum analyzer to the 2d and 3d harmonics of the assigned RF carrier frequency and observe any spurious emissions exceeding -50 dBm.

(8) Remove the dummy load and connect the transmitter and receiver in an RF loop as shown in figure 23-2. Adjust the RF attenuators for an RSL of -25 dBm as measured at the AGC test point.

(9) At the receive end, measure the loaded message bandwidth at the RF and IF interface points. The analyzer should be adjusted to observe the incoming occupied spectrum at least 10 MHz each side of the transmitter bandwidth.

(10) At the receive end, observe the baseband output with the analyzer and note any spurious signals ±10 MHz on each side of the required bandwidth.

(11) Photograph any spurious emissions exceeding specifications.

d. Multiplex Input Terminated. This test will show if the multiplex equipment is generating unwanted signals when connected to the baseband input. This test may also be performed by connecting the transmitter and receiver to their appropriate antennas.

(1) At the transmit end, terminate the multiplex input as shown in test condition (1), figure 23-2.

(2) At the transmit end, measure the level of any signals noted at the transmit baseband input (J24) with the frequency selective voltmeter and spectrum display unit or spectrum analyzer.

(3) Repeat paragraph 23-4d(2) at the transmit RF and IF interface test points.

(4) Connect the transmitter and receiver in an RF loop as shown in figure 23-2.

(5) Adjust the RF attenuators to provide an RSL of -25 dBm as measured at the receiver AGC test point.

(6) At the receive end, measure and photograph any spurious signals at the RF, IF, and baseband interface points.

e. Radio Interfering Signals at the Receiver Input.

(1) Turn the transmitter off or terminate the RF output into a dummy load as shown in figure 23-2.

(2) At the receive end, tune the spectrum analyzer to the exact center frequency of the transmitted signal and connect the analyzer input to the receive antenna system.

(3) Set the analyzer to observe the spectrum bandwidth when the transmitter is fully loaded as outlined in test condition (2), figure 23-2.

(4) Record and photograph any signals being received that fall within the occupied spectrum when the transmitter is turned off or its output is terminated.

(5) Change the spectrum analyzer to observe a bandwidth of ±5 MHz each side of the required message bandwidth. Measure and photograph any incoming signals. If the analyzer has insufficient gain, it may be connected to the output of the RF amplifier, the IF, or the baseband output.

(6) Photograph any incoming signals exceeding -80 dBm and record all pertinent data on the data sheets.

23-5. DATA RECORDING AND ANALYSIS.

a. Review all test data to ensure that it is valid and that the test results are within specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Assure that all photographs are suitably mounted, identified, and that all pertinent data is entered on the data sheets for future analysis of system performance.

c. Remove all test equipment and restore the system to its normal configuration.

d. If the equipment fails to meet specifications or emissions are present which would degrade system performance, notify the responsible activity of required corrective actions.

FREQUENCY SPECTRUM ANALYSIS DATA SUMMARY
(CCR 702-1-3)

PAGE _____ OF _____ PAGES

DATA SHEET

DATE (DAY, MO., YEAR)

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST TIME PERIOD START ___ Z	TEST TIME PERIOD STOP ___ Z	TEST ENGR SIGNATURE

A. TRANSMIT RF BANDWIDTH, SPURIOUS EMISSIONS AND CORRESPONDING RECEIVER RF, IF, AND BASEBAND FREQUENCY SPECTRUM

TEST RUN NUMBER	TEST CONDITIONS (TRANSMIT END) I IN TRAFFIC	II MUX TERMINATED	III BASEBAND WHITE NOISE LOADED LEVEL dBm	III BASEBAND WHITE NOISE LOADED LEVEL dBm0	IV BASEBAND TERMINATED	TRANSMIT PHOTO NO./PAGE BASEBAND Photo No.	BASEBAND Data Sheet Page	IF Photo No.	IF Data Sheet Page	RF Photo No.	RF Data Sheet Page	RECEIVE PHOTO NO./PAGE RF Photo No.	RF Data Sheet Page	IF Photo No.	IF Data Sheet Page	BASEBAND Photo No.	BASEBAND Data Sheet Page
1																	
2																	
3																	
4																	
5																	
6																	

B. TRANSMITTER RF OUTPUT CHARACTERISTICS

TRANSMITTER NUMBER	TEST CONDITION	OUTPUT FREQUENCY MHz	3dB BANDWIDTH MHz	SPURIOUS OUTPUT LEVEL -dB
1				
2				
3				
4				

C. BASEBAND SPURIOUS RESPONSE

TEST CONDITIONS ☐IF LOOP ☐RF LOOP

V MUX TERMINATED	VI BASEBAND NOISE LOADED dBm0	VII BASEBAND TERMINATED	RECEIVE BASEBAND PHOTO NO.	RECEIVE BASEBAND DATA SHEET PAGE

USACC FORM 533-R
1 JUL 79

EDITION OF 1 OCT 77 IS OBSOLETE

Figure 23-1. Frequency spectrum analysis data summary.

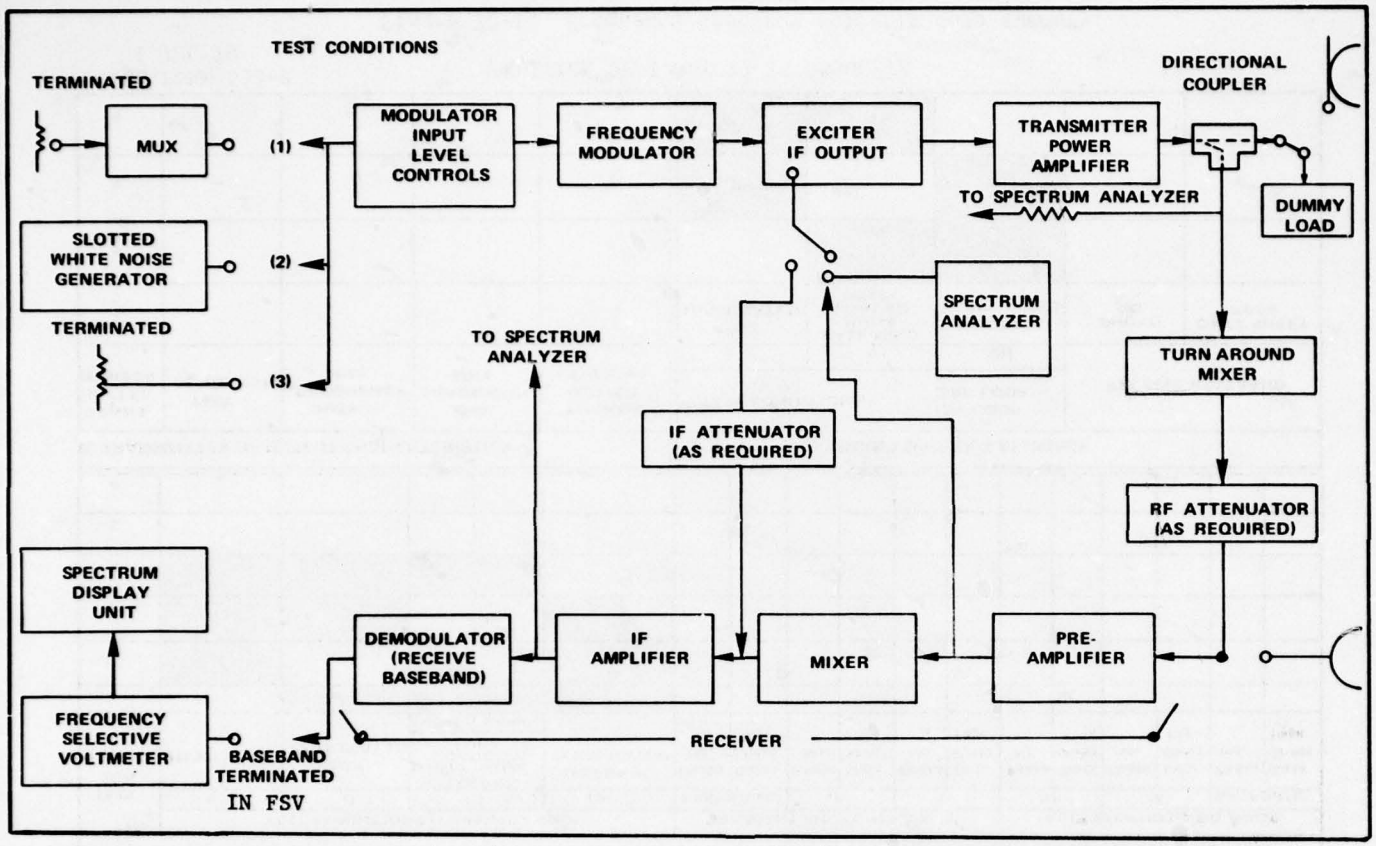


Figure 23-2. Radio spectrum analysis test setup.

CHAPTER 24

RECEIVER LOCAL OSCILLATOR SPURIOUS EMISSIONS, FREQUENCY ACCURACY, STABILITY, AND IMAGE REJECTION (DT-221)

24-1. GENERAL.

a. The purpose of this test is to measure the local oscillator frequency accuracy, stability, and output for spurious emission and image rejection.

b. The frequency accuracy of the local oscillator can be determined by averaging a number of discrete frequency measurements or by recording the oscillator output for a period of time and obtaining the median of the recorded intervals.

c. For the purpose of this test, the term local oscillator refers to the receiver klystron or crystal-controlled multiplier or frequency synthesizer.

d. Care must be taken to assure that the method used to measure the local oscillator output does not introduce instability or frequency shift into the oscillator output. If a local oscillator (decoupled) test point is not available, a decoupling resistive network should be used at the test point to prevent loading of the local oscillator by the test equipment.

e. In cases where a low frequency crystal oscillator frequency is multiplied to produce the local oscillator signal, it is preferred that the local oscillator frequency be measured directly rather than measuring the crystal oscillator and using the multiplying factor to calculate the local oscillator frequency.

f. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite testing as directed.

24-2. SPECIFICATIONS.

a. Electromagnetic interference specifications for commercial equipment shall be in accordance with MIL-STD-461A and MIL-STD-462.

b. The following criteria applies to the AN/FRC-162. (SCCC-73017)

(1) The receiver local oscillator leakage as measured at the RF interface point shall not exceed -85 dBm.

(2) The receiver input circuit selectivity characteristics from the combination of filters, tuned circuits, and circulators shall be such that all signals which are at the image frequency or are greater than 100 MHz away from the RF center frequency shall be down more than 80 dB with respect to the desired signal frequency as measured at the output of the baseband amplifier.

(3) The receiver shall deliver specified performance when the input RF signal varies from its assigned frequency by ±150 kHz. Frequency adjustments of the receiver to meet the performance requirements shall not be required more often than once every 90 days.

c. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) The receiver local oscillator frequency shall remain constant within $5x10^{-6}$ over any 60-day period. This requirement shall be met within 1 hour of the initial application of power under all operating and environmental conditions as specified.

(2) The receiver input circuit selectivity characteristics from the combination of filters, tuned circuits, and circulators shall be such that all signals which are at the image frequency or are greater than 100 MHz away from the RF center frequency shall be down more than 80 dB with respect to the desired signal frequency as measured at the IF output.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

24-3. TEST EQUIPMENT REQUIRED.

a. Spectrum analyzer.

b. RF sweep generator.

c. Frequency counter.

d. Digital-to-analog converter.

e. Stripchart recorder.

f. Digital printer.

g. Phase comparator and receiver.

h. Digital multiplex of pattern generator and error detector.

i. Oscilloscope camera.

j. Audio oscillator.

k. Power meter.

l. Digital voltmeter.

m. Frequency selective voltmeter.

n. Adapters, connectors, and attenuators as required.

24-4. TEST PROCEDURES. Record the assigned local oscillator frequency, RF carrier frequency, or the local oscillator crystal frequency, if applicable, on figure 19-2 (DD Form 2102).

a. Receiver Local Oscillator Frequency Accuracy (Average Method).

(1) Connect the test equipment as shown in figure 24-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Couple the RF frequency counter input to the receiver local oscillator through an appropriate attenuator, if required, to protect the frequency counter. Turn on the receiver and allow approximately 30 minutes for warmup and stabilization.

(3) Terminate the receive RF input terminals to preclude any extraneous signals from affecting the test results.

(4) Adjust the frequency counter input sensitivity control to provide a stable count of the local oscillator frequency. Manually record the measured frequency at 10-second intervals for a period of at least 15 minutes. If a worksheet is required for recording the 10-second intervals, use figure 24-2 (DD Form 2104).

(5) From the individual 10-second recordings, average the readings and enter the average frequency of all readings in the space provided on figure 24-2 (DD Form 2104).

(6) Calculate the local oscillator frequency accuracy from the following formula:

$$A = \frac{F_c - F_{med}}{F_c} \times 100 \text{ percent}$$

Where:

A = local oscillator frequency accuracy in percent.
F_c = assigned local oscillator frequency in MHz.
F_{med} = measured average (median) of the local oscillator frequency in MHz.

(7) Enter the calculated accuracy on figure 19-2 (DD Form 2102) and compare this value with the specifications in paragraph 24-2 as well as the manufacturer's technical literature for the receiver.

NOTE: The above only represents a spot measurement of the local oscillator accuracy and is generally acceptable during field testing; however, it would normally not be acceptable to verify equipment performance to a specification.

b. Receiver Local Oscillator Frequency Accuracy, Three-Level, Partial-Response Radio (Recording Method).

(1) If this test is being performed as part of an inplant acceptance procedure to verify compliance with paragraph 24-2b(3), record the results for a

90-day period. Essentially, it is a measure of the receiver to provide specified performance when the RF input signal varies from the assigned carrier frequency.

(2) Connect the test equipment as shown in figure 24-3 and allow approximately 30 minutes for warmup and stabilization.

(3) If the transmitter is tuned to the exact center frequency of the radio receiver, the turnaround mixer as shown in figure 24-3 can be omitted. If the mixer is used, insert sufficient attenuation at the mixer input to preclude damage.

(4) At the transmit end, terminate the message baseband and supervisory channel input, and measure the RF power output as described in DT-233. If this test has been previously performed, the power output measurement can be omitted.

(5) At the transmit end, measure the CW carrier frequency of the transmitter and record this frequency on figure 19-2 (DD Form 2102). For this measurement, the AFC should be turned off. If the transmitter is not at the exact assigned frequency with the AFC off, adjust the transmit oscillator circuit to the specified frequency. Record the measured and corrected frequency on figure 19-2 (DD Form 2102).

(6) At the receive end, observe that the received RF signal is at the exact center frequency of the receiver by measuring the discriminator output voltage or slightly adjusting the transmit frequency while observing the receive AGC voltage for any increase.

(7) With the attenuator, adjust the RSL to -71 dBm as correlated with the AGC voltage.

(8) At the transmit end, connect the audio oscillator output through a T-connector to the supervisory baseband input. Adjust the oscillator frequency to 4 kHz and an output level of -10 dBm. Ensure that the oscillator is set for 75 ohms. The other side of the oscillator T-connector should be connected to one channel of the chart recorder.

NOTE: If the recorder does not have an AC input, use an AC/DC converter for the transmit and receive tones.

(9) At both the transmit and receive ends, calibrate the stripchart for a 1-dB deviation from the -10 dBm reference tone.

(10) At the transmit end, connect a 12.6-mb/s pattern generator or digital multiplex to the transmit baseband input (J24) as shown in figure 24-3.

(11) At the receive end, connect a 12.6-mb/s error receiver or digital multiplex as shown in figure 24-3. Ensure that the transmit and receive baseband levels as measured with the oscilloscope are 1 VPP.

(12) Transmit and receive data for approximately 15 minutes and verify that the BER is $1x10^{-7}$ or better at an RSL of -71 dBm.

(13) Remove the transmitter input signals and, with the transmitter AFC off, adjust the RF carrier frequency to 150 kHz from the assigned frequency. Connect the modulation to the transmitter input and rerun the BER test for approximately 15 minutes. Verify that its received error rate did not exceed $1x10^{-7}$ and record the results in the comments section of figure 19-2 (DD Form 2102).

(14) Repeat paragraph 24-4b(13), except offset the transmit frequency by -150 kHz from the assigned frequency.

(15) Repeat the entire procedure for any other transmitter-receiver combinations that are to be tested.

(16) Based on paragraph 23-2b(3), if a long-term measurement (90 days) is required, retune the transmitter to the assigned frequency and turn the AFC on. Transmit data for a 90-day period and record the errors as shown in figure 19-2 (DD Form 2102). For the long-term measurement, the supervisory test tone and RSL should also be recorded so that a valid analysis can be made from the test data. Record all test results on figure 19-2 (DD Form 2102) and, if additional space is required, use figure 3-7 (DD Form 2091).

c. Receiver Local Oscillator Frequency Accuracy (Recording Method).

(1) To determine the frequency accuracy of the local oscillator through short- or long-term recordings and spot measurements as described in paragraph 24-4a, use one of the four methods described below.

(a) Convert the digital output of a frequency counter with a digital-to-analog converter and record the accuracy and stability on a stripchart recorder. This method is ideal for long-term measurements since the stripchart recording can readily identify any departures from prescribed limits.

(b) Use a digital printer in connection with the frequency counter and print the measured frequency over a period of time. Enter this data, as well as the data in subparagraph (a), above, on figure 3-2 (DCA Form (Test) T1-8) to arrive at the median value of the local oscillator during the recording period.

(c) Place the output of the local oscillator into a phase comparator where the local oscillator frequency will be compared to a highly stable oscillator or a primary standard receiver. The result will be a stripchart recording showing any departure of the local oscillator frequency from the primary standard.

(d) To determine the long-term stability, use a programmable calculator as shown in figure 24-4. This method is less time-consuming and more accurate than most of the above methods since the calculator can obtain a large number of samples over a short period of time. Further, the problem of reducing the recorded data is eliminated. If this method is used, the calculator program should include:

1. Number of samples taken.

2. Average frequency.

3. Assigned carrier frequency.

4. The lowest frequency.

5. The highest frequency.

6. Median value from all samples.

7. Total time recorded.

8. A plot of the stability during the recorded period based on all samples.

(e) For the three-level, partial-response radio, connect the test equipment as shown in figure 24-1 or 24-4, depending on the method to be used.

(f) Apply power to the receiver under test and observe that the local oscillator stabilizes to the specified frequency. If this is a long-term recording to verify compliance of the equipment to paragraph 24-2c(1), record the frequency for a 60-day period. Reduce the recorded data to a median value as previously discussed and record the final frequency accuracy and stability on figure 24-2 (DD Form 2104).

(g) For the fully digitized radio, AN/FRC-( ), repeat paragraph 24-4c(1)(f).

(2) If required, repeat paragraph 24-4c for other receivers to be tested.

d. Receiver Local Oscillator Leakage, Three-Level, Partial-Response Radio.

(1) Connect the spectrum analyzer to the RF interface point as shown in figure 24-1. For this test, the antenna must be diconnected and care exercised to ensure that the test leads to the analyzer are not acting as an antenna.

(2) Turn off all instation transmitters and tune the spectrum analyzer to the receiver local oscillator frequency. Record the measured level on figure 24-5 (USACC Form 636-R).

(3) Tune the analyzer or set the dispersion control to observe the spectrum between 3 to 10 GHz and photographically record the results if any signals exceed -85 dBm. Mount the photographs on figure 5-2 (DD Form 2093) and annotate the frequency and level of any signals.

(4) As an alternate method, use an electromagnetic analyzer and manually or automatically sweep the frequency spectrum between 3 and 10 GHz. If this method is used, set the electromagnetic analyzer test set threshold level for -85 dBm and manually or automatically sweep the required spectrum. If any signals are noted above -85 dBm, record the frequency and level on figure 19-2 (DD Form 2102). If an automatic printout is used, attach the printout to the data sheet.

e. Radio Receiver Image Rejection, Three-Level, Partial-Response Radio.

(1) Use the functioning transmitter as a signal source or connect a sweep generator to the receiver RF input as shown in figure 24-3. The preferred method would be with a sweep generator due to the ease of changing the power level and RF frequency input to the receiver.

(2) Adjust the sweep generator output to correspond to an RF signal level of -80 dBm as verified by the AGC voltage.

(3) Set the frequency selective voltmeter to a 3.1-kHz bandwidth, tune to 6 MHz, and record the noise level on figure 24-5 (USACC Form 636-R).

(4) Tune the RF sweep generator to the received RF carrier frequency plus 100 MHz and adjust the sweep generator output for 0 dBm.

(5) Record the noise level at the receiver output (J2).

(6) Adjust the sweep generator frequency to the received RF carrier frequency minus 100 MHz and record the noise level at the receive baseband output (J2). Repeat the procedure for ±110, ±120, ±130, ±140, ±150, and ±160 MHz from the receiver carrier frequency. Record the results on figure 24-5 (USACC Form 636-R).

(7) Repeat paragraph 24-4d for the fully digitized radio, except make the measurements at the IF output. Also replace the frequency selective voltmeter with a spectrum analyzer and set the analyzer dispersion control to cover 80 MHz each side of the receiver carrier frequency. Record the level of any image signals on figure 24-5 (USACC Form 636-R).

24-5. DATA RECORDING AND ANALYSIS.

a. Review all test data for compliance with the applicable specifications and for validity. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet the applicable specifications, notify the responsible activity of required corrective actions.

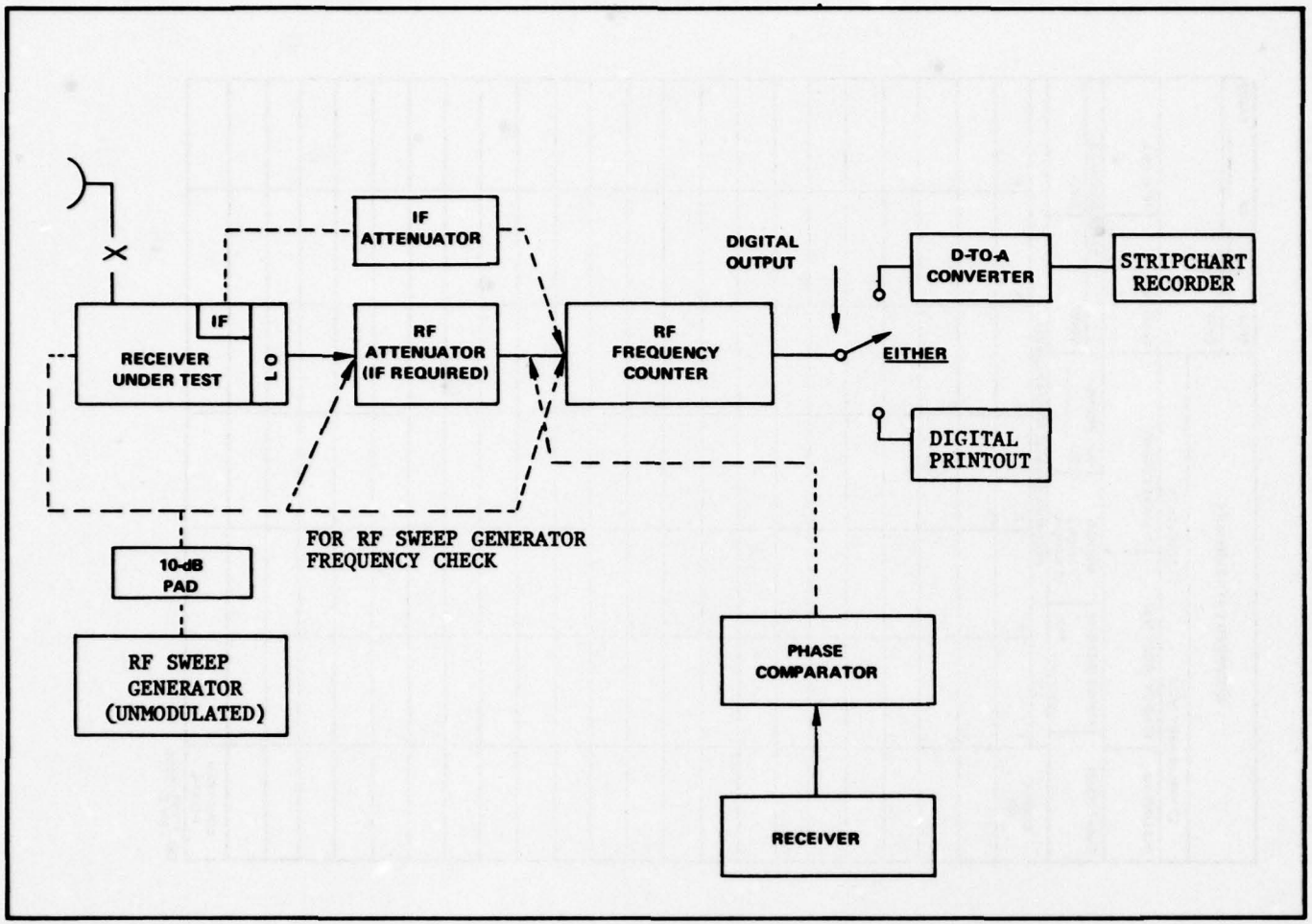


Figure 24-1. Receiver local oscillator test setup.

RECORDED DATA SUMMARY

PAGE _____ OF _____ PAGES

DATE

☐ PRELIMINARY DATA ☐ FINAL DATA

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECH. INIT.

CHART SPEED	SAMPLE INTERVAL	METHOD	RECORDING NO.	DATE/TIME GROUP	
	_____ MIN	☐ SAMPLE ☐ MEDIAN	_____	START	END

SAMPLE NO.	RECORDER CHANNEL AND PARAMETER					
	1.	2.	3.	4.	5.	6.
LONG TERM MEDIAN						

DD FORM 1 SEP 77 2104

Figure 24-2. Recorded data summary.

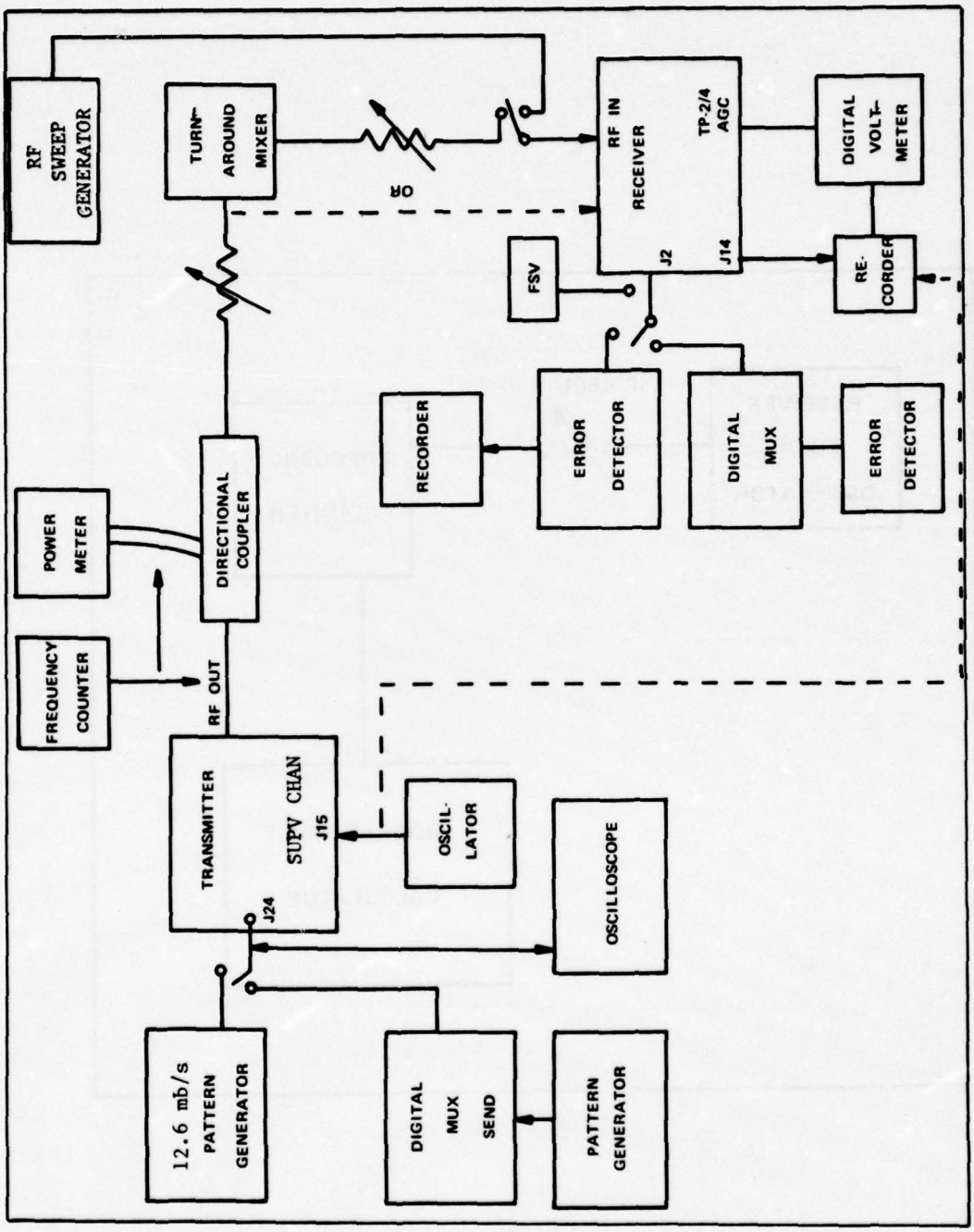


Figure 24-3. Local oscillator performance test setup.

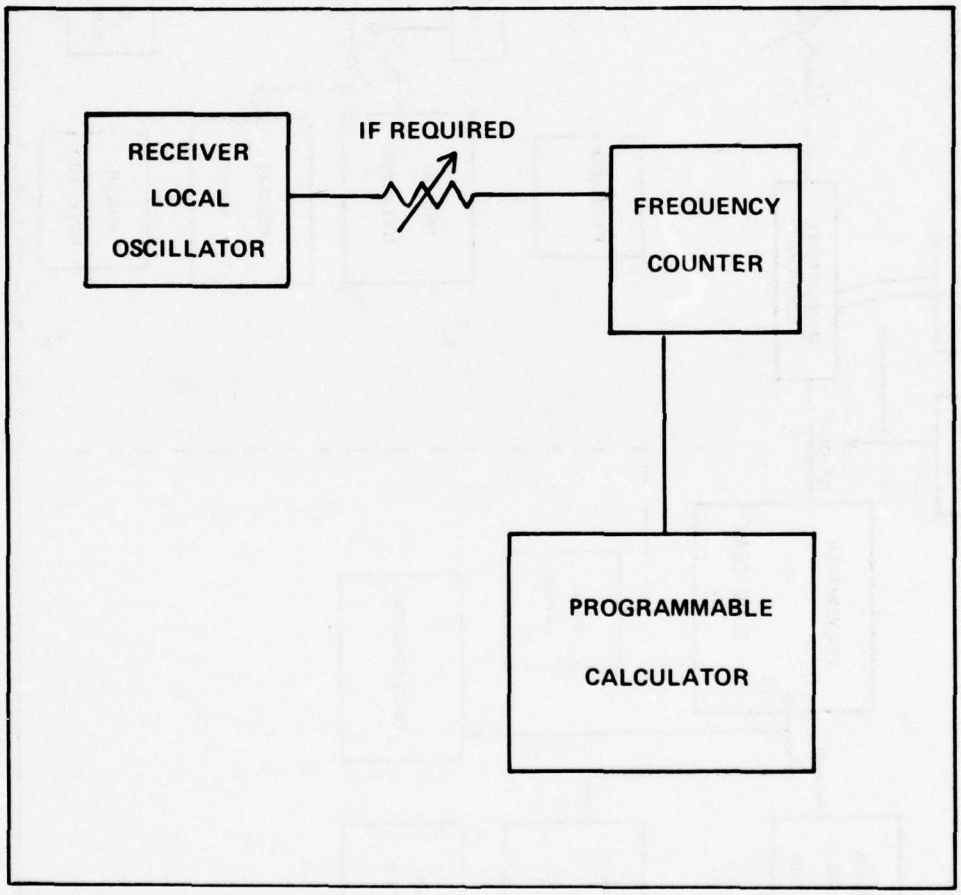


Figure 24-4. Receiver local oscillator (calculator method) test setup.

RECEIVER LOCAL OSCILLATOR IMAGE REJECTION (CCR 702-1-3) DATA SHEET			PAGE OF PAGES / DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
IF FREQ MHz	ASSIGNED RF FREQ MHz	TYPE RADIO 3LPR ☐ DIGITAL ☐	METHOD USED

IMAGE REJECTION				
FREQ (MHz)	NOISE LEVEL (dBm)			
	RCVR SER NO.	RCVR SER NO.	RCVR SER NO.	RCVR SER NO.
+100				
-100				
+110				
-110				
+120				
-120				
+130				
-130				
+140				
-140				
+150				
-150				
+160				
-160				

LOCAL OSCILLATOR LEAKAGE				
FREQ (MHz)	LEVEL (dBm)			

USACC FORM 636-R
1 MAY 79

Figure 24-5. Receiver local oscillator image rejection data sheet.

CHAPTER 25

RADIO FREQUENCY SPECTRUM BANDWIDTH (DT-222)

25-1. GENERAL.

a. The purpose of this test is to measure and determine the spectrum width occupied by 99 percent of the total power radiated at the transmitter RF interface point.

b. To provide for optimum use of the allocated spectrum in the fully digitized radio, a scrambler and descrambler are used. The purpose of the scrambler is to ensure an apparent randomness of the modulating data stream independent of the actual multiplex output. Inclusion in the multiplex output stream of periodic occurrences of such signals as framing patterns, multiplex static data, or absence of data will produce strong discrete spectral components in the modulating envelope and, consequently, in the radiated transmitted signal unless a random technique is used. This particular modulating and demodulating technique is not used in the AN/FRC-162.

c. This test applies to the AN/FRC-162 as well as the AN/FRC-( ).

d. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite testing as directed.

25-2. SPECIFICATIONS.

a. The following criteria applies: (MIL-STD-188-322)

(1) The operating frequencies for bands 1 and 2 shall be 4.4 to 5.0 GHz and 7.125 to 8.4 GHz, respectively.

(a) The transmitter spectrum in any 4-kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth, shall be as specified by the following equation:

$$A = 35 + 0.8\,(P - 50) + 10 \log_{10} B$$

Where:

A = attenuation (in dB) below the mean output power level
P = percent removed from the carrier frequency
B = authorized bandwidth

(b) The attenuation shall not be less than 50 dB. Attenuation greater than 80 dB is not required.

(2) The operating frequencies in band 3 shall be 14.4 to 15.4 GHz.

(a) The transmitter spectrum in any 1-MHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth, shall be as specified by the following equation:

$$A = 11 + 0.4\ (P - 50) + 10\ \log_{10}B$$

(b) The attenuation shall not be less than 11 dB. Attenuation greater than 56 dB is not required.

b. For the AN/FRC-162, the occupied bandwidth, measured at the output of the transmitter, is the frequency bandwidth occupied by 99 percent of the radiated power and shall be less than 14 MHz. The radiation outside the range of 15 MHz each side of the RF center frequency shall be less than 50 dBm. These requirements shall be met with a peak deviation of 3.14 MHz of the 12.6 mb/s TDM, 8.5-MHz radio pilot, and a peak deviation of 700 kHz of the 8.1-MHz orderwire. (SCCC-73017)

c. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) The attenuation of the transmitted spectrum relative to the mean unmodulated power in a 4-kHz band shall not be less than that specified by the following equation:

$$A = 35 + 0.8\ (P - 50) + 10\ \log_{10}B$$

Where:

A = attenuation (in dB) below the mean output power
P = percent removed from the authorized center frequency relative to the authorized bandwidth
B = authorized bandwidth in MHz

(2) These attenuation values shall govern for frequencies removed from the center frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth. In addition, attenuation in these areas shall not be less than 50 dB. Attenuation greater than 80 dB is not required.

(3) The radio shall satisfy the above emission requirements for the data rate and transmitter bandwidth combinations specified in table 10-1.

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

25-3. TEST EQUIPMENT REQUIRED.

a. 12.6-mb/s pattern generator (three-level, partial-response or NRZ).

b. Oscilloscope.

c. Digital multiplexer.

d. Oscillator.

e. 192-kb/s pattern generator.

f. Directional coupler.

g. Spectrum analyzer.

h. X-Y recorder.

i. Turnaround mixer.

j. Camera.

25-4. TEST PROCEDURES.

a. Three-Level, Partial-Response Radio AN/FRC-162.

(1) Connect the test equipment as shown in figure 25-1 and allow approximately 30 minutes for warmup and stabilization.

(2) If the test is performed over a radio link, omit the turnaround mixer shown in figure 25-1. The transmitter must be tuned to the exact center frequency of the receiver.

(3) Connect the spectrum analyzer through suitable attenuation to the directional coupler as shown in figure 25-1. It may also be connected directly to the transmitter output or RF test point provided adequate attenuation is used to protect the analyzer.

(4) With the transmitter baseband and supervisory channel terminated, establish the RF carrier frequency on the center graticule of the analyzer. Adjust the vertical amplitude of the analyzer to position the unmodulated carrier to the top graticule of the CRT.

(5) Calibrate the X and Y axes of the X-Y recorder with the Y-axis calibrated for 0 to 80 dB. The X-axis should be calibrated for a sweep of 30 MHz (15 MHz each side of the RF center frequency).

(6) Adjust the spectrum analyzer controls as follows:

(a) IF bandwidth to 300 kHz.

(b) Scan width to 5 MHz per division.

(c) Scan time to 5 seconds.

(d) Video filter to 10 Hz.

(e) Scan mode to manual/single.

(f) Scan trigger to video.

(7) Apply a 12.6-mb/s three-level, partial-response signal to the transmitter baseband input as shown in figure 25-1. The signal can be simulated from a multiplex having an aggregate bit stream of 12.6 mb/s or from a pattern generator. Measure the input signal and ensure it is 1 VPP ±0.25 volt.

(8) Connect an audio oscillator to the supervisory channel input and adjust the oscillator for -10 dBm at a frequency of 4 kHz.

(9) Plot the RF spectrum on figure 3-4 (DD Form 2094) by pressing the scan mode switch of the analyzer. Photographs of the spectrum may also be taken if required. If photographs are taken, mount them on figure 5-2 (DD Form 2093). Ensure that all pertinent data is identified and annotated on the data sheet to include the information contained in paragraph 25-4a(6). Also record the same information on the X-Y plot of the spectrum bandwidth.

(10) If more than one radio is being tested, prepare an overlay similar to that shown in figure 25-2 to assure that all radios are within specifications.

b. Radio Set AN/FRC-( ). This test may be performed in an RF loop or over the link as shown in figure 25-1. However, the results should be the same regardless of the method used.

(1) Connect the test equipment as shown in figure 25-1 and connect a pattern generator with the applicable data rate to the transmitter MBS input. The pattern generator must provide an NRZ format to the MBS input. Adjust the generator output for 1 VPP. A digital multiplex may be used instead of the pattern generator providing the multiplex data rate and format is compatible with the MBS input.

(2) Connect a 192-kb/s pattern generator to the SCBS as shown in figure 25-1.

(3) Adjust the analyzer and X-Y recorder controls as outlined in paragraphs 25-4a (4), (5), and (6), above, for the data rate at which the radio is to be tested, except the analyzer sweep width should be adjusted to display a frequency range of 250 percent of the authorized bandwidth.

(4) Once the analyzer and X-Y recorder have been calibrated, plot the RF spectrum on figure 3-4 (DD Form 2094). Spectrum photographs may also be taken if required. If photographs are taken, mount them on figure 5-2 (DD Form 2093). Ensure that all pertinent data is identified and annotated on the data sheet to include the information contained in paragraph 25-4a(6). Also record the same information on the X-Y plot of the spectrum bandwidth.

(5) Repeat the above procedure for any additional radios to be tested.

25-5. DATA RECORDING AND ANALYSIS.

a. Review all test data to ensure that it is valid and complete, and that all salient points are identified on the chart recording and spectrum photographs. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specifications, notify the responsible activity of required corrective actions.

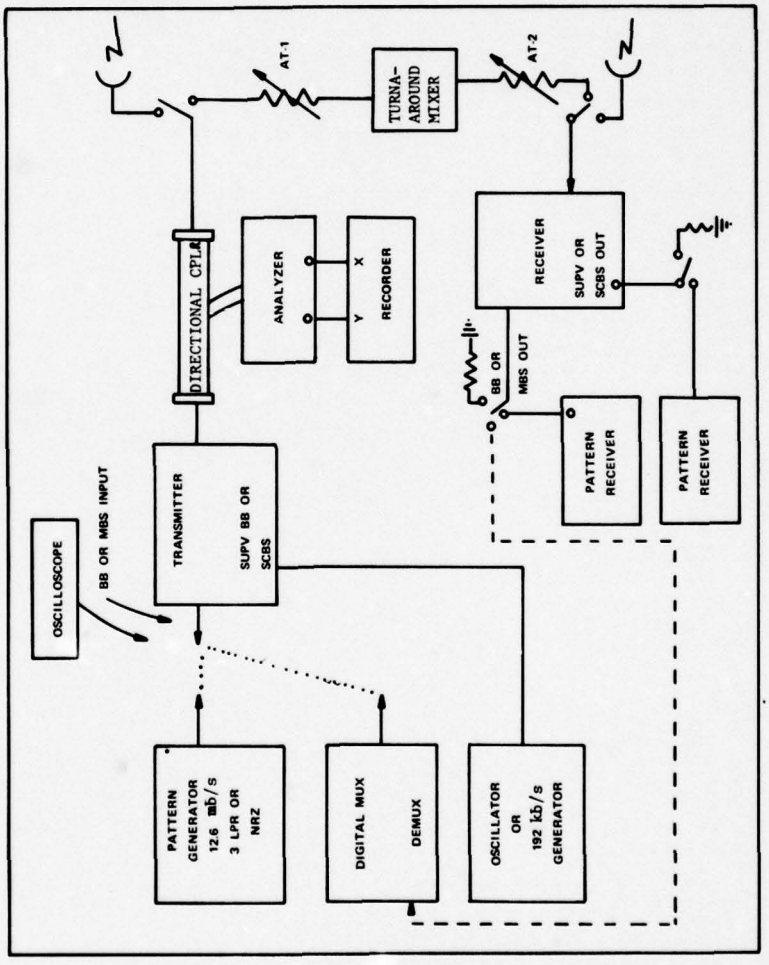


Figure 25-1. Radio frequency spectrum bandwidth test setup.

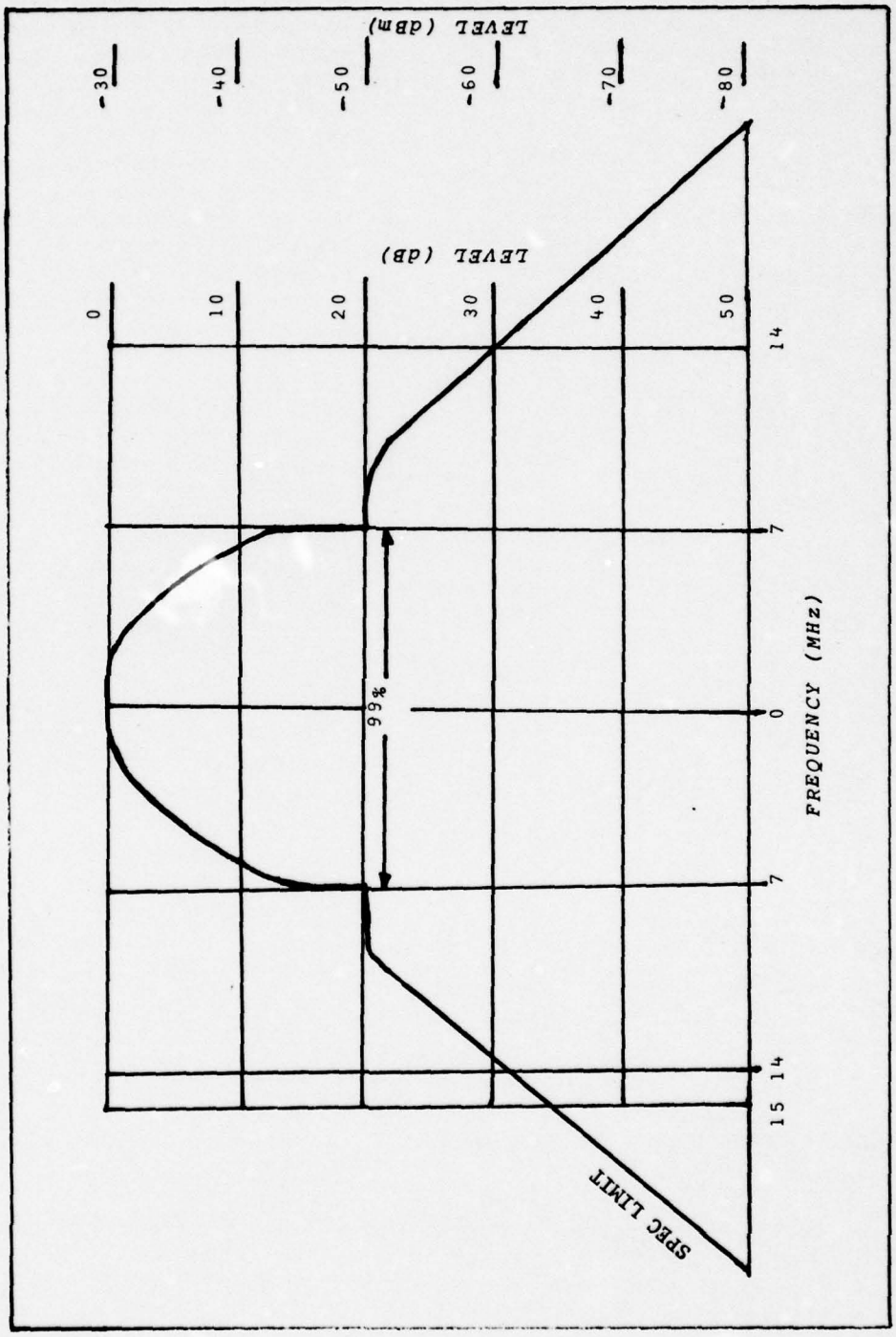


Figure 25-2. Typical overlay of spectrum bandwidth (AN/FRC-162).

CHAPTER 26

RECEIVER NOISE FIGURE (DT-223)

26-1. GENERAL.

a. The purpose of this test is to measure the receiver noise. Basically, the noise figure expresses the thermal and basic noise contributions of the receiver RF and IF sections. This noise primarily determines the receiver's sensitivity and, therefore, its noise threshold.

b. The noise figure may be measured by the automatic or manual method. The automatic method is more accurate and less time-consuming and, therefore, should be used whenever possible. The noise figure of the individual receiver sections can be measured (when access points are available) or as a total noise figure representing all subsections connected in tandem. The entire procedure will be repeated for each receiver subsection or total receiver to be tested.

(1) *Automatic method.* This method makes use of a noise figure meter, which uses the receiver IF signal power to measure the noise figure of the receiver, including the IF section. However, the noise figure meter cannot be used to measure the noise figure of the IF section alone since the meter works on the IF of the receiver.

(2) *Manual method.* This method is used to measure the noise figure of the RF section of the receiver, as well as the IF section and total receiver noise using an IF/RF power detector. This power detector may be any instrument capable of detecting the output of the RF or IF. The most versatile instrument for this measurement is the spectrum analyzer; however, in many cases an RF voltmeter, power meter, or an oscilloscope with a suitable detector may be used.

c. Several possible sources of error must be considered when measuring the noise figure of a receiver such as errors caused by impedance matching, image response, and spurious signals. As an example, one of the most commonly used noise figure meters can have as much as 1-dB error, excluding the noise source, even though the unit may be accurately calibrated.

d. This test may be performed on the AN/FRC-162 as well as the AN/FRC-( ).

e. This test may be performed during acceptance testing of contractor EF&I systems to ensure that the systems conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed.

26-2. SPECIFICATIONS.

a. The radio receiver noise figure shall be: (MIL-STD-188-322)

(1) Less than 10 dB below 10 GHz.

(2) Less than 14 dB above 10 GHz.

b. The AN/FRC-162 receiver noise figure shall be less than 12 dB measured at the IF output with the input applied at the RF interface point. (SCCC-73017)

c. The AN/FRC-( ) receiver noise figure, measured with respect to the RF interface point, shall not exceed 10 dB. (CCC-74049)

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

26-3. TEST EQUIPMENT REQUIRED.

a. Noise figure meter.

b. Noise source based on the frequency of the radio under test.

c. Spectrum analyzer.

d. Attenuators, adapters, and cables.

26-4. TEST PROCEDURES.

a. Automatic Method. The procedure for measuring the noise figure is the same for the RF amplifier and mixer or down converter section and the total receiver noise figure.

(1) Complete the top portion of figure 26-1 (DD Form 2123).

(2) Connect the test equipment as shown in figure 26-2 and allow approximately 30 minutes for warmup and stabilization.

NOTE: The 10-dB attenuator inserted between the noise source and the receiver input will provide for more accurate measurements at low noise levels. This device also serves as an impedance matching and isolating unit.

(3) Calibrate the test cables to determine any loss and consider these factors in the final test results. Turn on the noise source and adjust the current as specified for the gas tube in use. This will normally be stamped on the side of the noise source.

(4) Calibrate the noise figure meter for infinity and zero positions on the noise figure meter as specified in the operating instructions.

(5) Set the meter function switch to noise figure and note the noise figure as read on the meter. Record this value on the data sheet.

(6) Note any corrections required such as the 10-dB attenuator and cable losses between the noise source and the receiver under test including

variations in the output level of the noise tube as specified by the manufacturer. Record all such corrections on the data sheet.

(7) Subtract the total corrections from the measured noise figure and record the corrected noise figure on the data sheet.

b. Manual Method. The procedure for noise figure measurement of the RF/IF components or total receiver noise is basically the same as the foregoing.

(1) Select the unit or combinations of units to be tested and connect the test equipment as shown in figure 26-2. The 10-dB precision RF attenuator is required only when low noise equipment is being tested. The signal input and output of the unit or section under test must be completely isolated from the remainder of the receiver for accurate measurements.

(2) Disable the AGC circuit if the IF section is included in the measurement, unless the AGC switching time is fast enough to preclude interfering with the test results. In systems where there are no provisions for disabling the AGC, it is obviously not practical to do so. If not disabled, the measured noise figure will be a true indication of the noise figure of the equipment in its operational environment.

(3) With the noise tube off and the RF attenuator set for zero attenuation, adjust the spectrum analyzer for a convenient reference display and note the level on the display graticule.

(4) Turn the noise tube on and adjust the variable attenuator to obtain the previously noted reference level on the spectrum analyzer. The amount of attenuation inserted is proportional to the noise figure and is referred to as the Y-factor. Record this value of the Y-factor on the data sheet. If a 10-dB attenuator is used between the noise source and the unit or subsection under test, add 10 dB to the amount of attenuation inserted and record as the Y-factor.

(5) The Y-factor can be converted to a noise figure by means of a Y-factor chart which is usually supplied with the noise source. If this chart is not available, the noise figure may be calculated using the following formula:

$$NF = 15.2 - 10 \log_{10} \left(\frac{N_2}{N_1} - 1 \right)$$

Where:

$\frac{N_2}{N_1}$ = the ratio (in dB) of the measured noise power with the noise tube off and on

N_2 = noise tube on
N_1 = noise tube off

(6) Note any corrections that are required such as cable losses along with variations in the output level of the noise tube from 15.2 dB as specified for the test equipment. Record the final noise figure on the data sheet.

26-5. DATA RECORDING AND ANALYSIS.

a. Complete the data sheet and verify the accuracy and completeness of the test data. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the unit fails to meet specified performance, notify the responsible activity of required corrective actions.

RECEIVER NOISE FIGURE DATA

PAGE _____ OF _____ PAGES

DATE

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	METHOD USED: ☐ AUTOMATIC ☐ MANUAL	ENGR. INIT.	TECHN. INIT.

RCVR NO.	EQUIPMENT TESTED	"Y" FACTOR	NF FROM "Y" FACTOR	AUTOMATIC MEASURED NF	CORRECTIONS			TOTAL CORRECTIONS TO NF	CORRECTED NF
					PRE-SELECTOR BP FILTER	CABLING	PRECISION ATTENUATOR		
	RF AMPLIFIER								
	RF AMPL. & MIXER/ DOWN-CONVERTER								
	TOTAL RECEIVER								
	RF AMPLIFIER								
	RF AMPL. & MIXER/ DOWN-CONVERTER								
	TOTAL RECEIVER								
	RF AMPLIFIER								
	RF AMPL. & MIXER/ DOWN-CONVERTER								
	TOTAL RECEIVER								
	RF AMPLIFIER								
	RF AMPL. & MIXER/ DOWN-CONVERTER								
	TOTAL RECEIVER								

DD FORM 1 SEP 77 2123

Figure 26-1. Receiver noise figure data sheet.

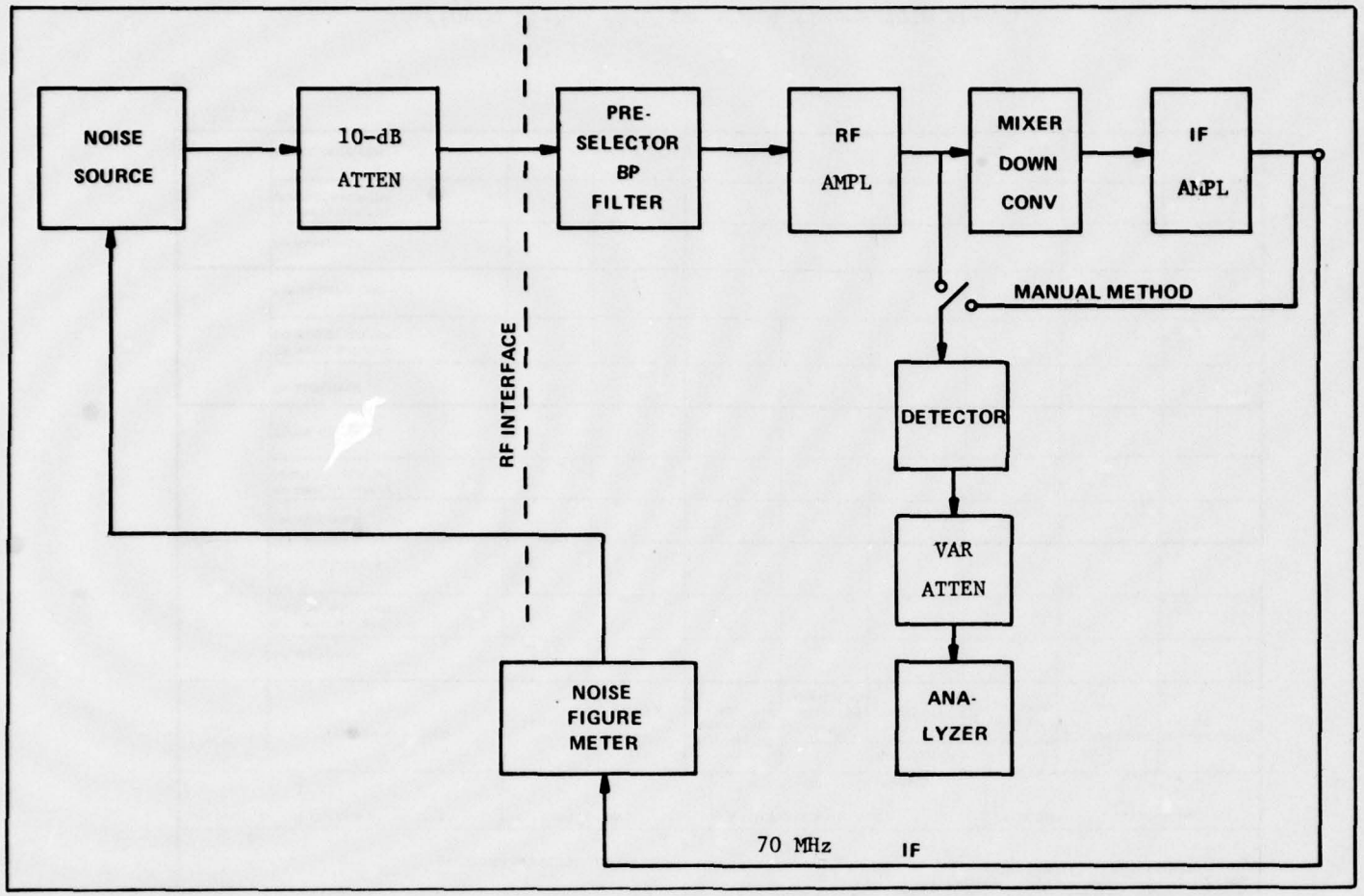


Figure 26-2. Receiver noise figure test setup.

CHAPTER 27

RECEIVER RF INPUT POWER VS AGC OR IF VOLTAGE QUIETING CHARACTERISTICS (DT-224)

27-1. GENERAL.

a. The purpose of this test is to:

(1) Calibrate the radio receiver in terms of the RF signal power or RSL versus the AGC volts or the IF signal power DC voltage which can then be used as a measure of the RSL.

(2) Measure the noise in selected slots of the baseband versus the RSL, that is, the noise quieting characteristics. This data would normally be compared to and correlated with the noise power ratio (NPR) test results; however, in the case of the digital radio, the NPR is not considered a valid test. If an NPR test is performed on the AN/FRC-162, it should be loaded as a regular FM radio.

b. The data from these meaurements wil be used to plot curves of: AGC voltage of IF power (DC) voltage and receiver noise quieting, each versus the radio receiver input power level (RSL). The AGC voltage or the IF power (DC) voltage provides a radio receiver calibration which can be used to measure the RSL. The quieting curves are also used to determine the radio receiver 20-dB quieting point and to determine the receiver FM threshold.

c. The receiver quieting curves provide information about receiver performance. The 20-dB quieting point provides information on receiver sensitivity. The receiver threshold, which can be directly extrapolated from the curves, provides a cursory examination of the receiver noise figure and bandwidth. The most important aspect, however, is the thermal noise contribution of the receiver which can be determined from the quieting curves.

d. This test is not applicable to the fully digitized radio at the baseband level; however, it may be performed on these radios between RF and IF. The results could then be correlated with the receiver small signal performance and dynamic range as described in DT-226.

e. This test may be performed on contractor EF&I systems to ensure that they conform to contract specifications or other applicable documents. It may also be performed by installer or quality assurance personnel during onsite testing as directed.

27-2. SPECIFICATIONS.

a. The output noise level measured in the baseband of the AN/FRC-162 shall vary inversely dB for dB within 1 dB with the level of the unmodulated RF input signal, as the input level varies between the improvement threshold and -45 dBm. Noise shall be measured in a nominal 4-kHz slot near the top of the occupied baseband. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

27-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. RF sweep generator.

c. Spectrum display unit (optional).

d. Electronic voltmeter.

e. Logarithmic/linear amplifier (if required).

f. Power meter with thermistor mount.

g. Precision attenuator.

h. Frequency selective voltmeter.

27-4. TEST PROCEDURES. The procedures contained in this paragraph are applicable to the AN/FRC-162 and the AN/FRC-( ). The tests may have to be modified to some extent once the fully digitized radios have been fielded.

a. Calibration.

(1) Complete the top portion of figure 27-1 (DD Form 2122). A separate sheet will be required for each receiver to be tested. Modify the slot freqencies on the form to cover those used in the procedures.

(2) Calibrate the RF sweep generator output by connecting the power meter and thermistor mount as shown in figure 27-2. The output power from the generator should be checked at each power level to be used during the test. If the generator internal attenuator and power output level is found to be accurate, after initial calibration, the power meter will no longer be required. If however, there is any doubt as to the generator accuracy, the power meter should be used for each level of receiver input. The loss in the cable used to connect the generator to the receiver under test should also be measured and compensated for during the test.

(3) Tune the generator output frequency to the center frequency of the receiver and measure the output over the range of -110 to -20 dBm.

NOTE: The 10-dB attenuator is inserted at the output of the generator to minimize the effects of slight impedance mismatches between the generator and the receiver under test.

(4) Before beginning the test, perform any alinement or required maintenance in accordance with the applicable technical manual.

b. Three-Level, Partial-Response Radio AN/FRC-162.

(1) Record the baseband slot width of the frequency selective voltmeter on figure 27-1 (DD Form 2122). In most cases, this will be 3.1 kHz. Set the frequency selective voltmeter to 75 ohms and connect its input to the receiver baseband output (J2). Allow approximately 30 minutes for warmup and stabilization. Complete all applicable blocks of the data sheet to include the baseband frequencies at which the measurements are to be performed.

(2) Connect the calibrated RF sweep generator output to the receiver input as shown in figure 27-2. This would be at the RF interface point, ahead of any preamplifier, preselector, or mixer.

(3) While monitoring the AGC voltage or IF signal power, set the RF sweep generator output power to -50 dBm and slightly adjust the generator frequency for maximum AGC or IF signal power.

(4) Starting at an RF signal power input (RSL) approximately 20 dB lower than the FM threshold, increase the generator output in 5-dB steps until the RF signal power is approximately 6 dB below the FM threshold. At each step, measure and record the noise power in the baseband with the frequency selective voltmeter. Initial measurements should be at the top baseband slot which is 6.4 MHz.

(5) Continue to increase the receiver input power, except now by 2-dB steps until a point at least 6 dB above threshold is reached. Return to 5-dB steps and continue to increase the receiver input power until saturation occurs. This will be indicated by no further increase in AGC or IF signal power with any increase in the receiver input power. At each of the above steps, record the baseband noise power in the top slot as read on the frequency selective voltmeter.

(6) Record the corresponding RSL, AGC voltage or IF power, and the noise power in the baseband slot for each attenuator setting on figure 27-1 (DD Form 2122).

(7) Ensure that an adequate number of measurements are recorded to provide a smooth curve when plotted on figure 27-3 (USACC Form 596-R). A typical plot of the receiver quieting curve for a regular FM radio is shown in figure 27-4.

(8) Repeat paragraphs 27-4b (1) through (7) at baseband slot frequencies of 2.4 and 4.4 MHz.

(9) Repeat the entire procedure for other receivers to be tested.

NOTE: If directed by the team chief, the noise power over the entire message baseband can be measured with a noise receiver; however, the availability of the required filters may preclude this type of measurement.

c. Radio Set AN/FRC-( ) (Digital). The quieting characteristics of the fully digitized radio can be measured in a manner similar to that of the AN/FRC-162 radio except that the noise power in the baseband slots will be omitted.

(1) Connect an electronic voltmeter to the IF output test point of the receiver as shown in figure 27-2.

(2) Connect the calibrated RF sweep generator output to the receiver input as shown in figure 27-2. This would be at the RF interface point.

(3) While monitoring the IF signal power, set the RF sweep generator output power to -50 dBm and adjust the generator output frequency for maximum AGC or IF signal power. If the frequency of the generator is different than the assigned frequency, it would indicate that the AFC or local oscillator is off frequency.

(4) Starting at an RF signal power input (RSL) approximately 20 dB lower than the FM threshold, increase the generator output in 5-dB steps until the RF signal power is approximately 6 dB below the FM threshold.

(5) Continue to increase the receiver input signal, except now by 2-dB steps until a point at least 6 dB above threshold is reached. Return to 5-dB steps and continue to increase the receiver input power until saturation occurs. This is the point at which no further increase in AGC or IF power occurs with an increase in RSL.

(6) Record the corresponding RSL, AGC voltage, and IF signal power at each attenuator setting of the signal generator on figure 27-1 (DD Form 2122). Plot a curve of the AGC voltage and IF signal power versus receiver input power on figure 27-3 (USACC Form 596-R).

(7) Repeat the entire procedure for the remaining radio receivers to be tested.

27-5. DATA RECORDING AND ANALYSIS.

a. Plot the data from figure 27-1 (DD Form 2122) on figure 27-3 (USACC Form 596-R). For the graph, choose a scale that is appropriate for the range of RSL, AGC, IF signal, and slot noise in the baseband for the AN/FRC-162. The scale should be chosen so as to clearly show that portion of the data from a low RSL to above FM threshold, to facilitate identification of the 20-dB quieting point.

b. For the AN/FRC-162:

(1) Determine the receiver 20-dB quieting point for the upper frequency slot (6.4 MHz) determined from the curve by drawing a line at the point where the noise is reduced 20 dB from its maximum value. Record the corresponding RSL on figure 27-1 (DD Form 2122). Also determine the 20-dB quieting point

for each of the baseband slot frequencies used and record them on the data sheet.

(2) Determine the FM threshold for the upper frequency slot measured by drawing a limiting curve adjacent to the measured curve and ascertaining the point or points at which a 1-dB separation occurs between the two curves (fig. 27-4). Record the corresponding RSL on the data sheet and compare the measured values of FM threshold with the calculated value obtained from the following equation:

$$\text{FM threshold RSL (dBm)} = -164 \log B_{if} + NF$$

Where:

B_{if} = IF bandwidth in Hz
NF = receiver noise figure in dB

c. For the AN/FRC-( ), plot the AGC voltage and IF signal power versus RSL.

d. Verify the accuracy and completeness of the test data and summarize the test results on figure 3-7 (DD Form 2091).

e. Remove all test equipment and restore the system to its normal configuration.

f. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

RECEIVER FM QUIETING DATA				PAGE ____ OF ____ PAGES DATE
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.
RECEIVER NO.	BASEBAND TLP ____ dBm	SLOT WIDTH OF FSVM	SLOT WIDTH CORRECTION TO 3.1 KHz ____ dB	

RSL	AGC/IF SIGNAL VOLTS (DC)		POST DET. COMBINER DC CONTROL VOLTS	NOISE POWER IN BASEBAND SLOT								
				BASEBAND SLOT FREQUENCY								
				KHz			KHz			KHz		
-dBm	AGC	IF		MEAS. dBm	CORR. TO 3.1 KHz	dBm0	MEAS. dBm	CORR. TO 3.1 KHz	dBm0	MEAS. dBm	CORR. TO 3.1 KHz	dBm0

20 dB QUIETING RSL LEVEL			FM THRESHOLD RSL		
BASEBAND SLOT FREQUENCY			BASEBAND SLOT FREQUENCY		
kHz	kHz	kHz	kHz	kHz	kHz
dBm	dBm	dBm	dBm	dBm	dBm

DD FORM 1 SEP 77 2122

Figure 27-1. Receiver FM quieting data sheet.

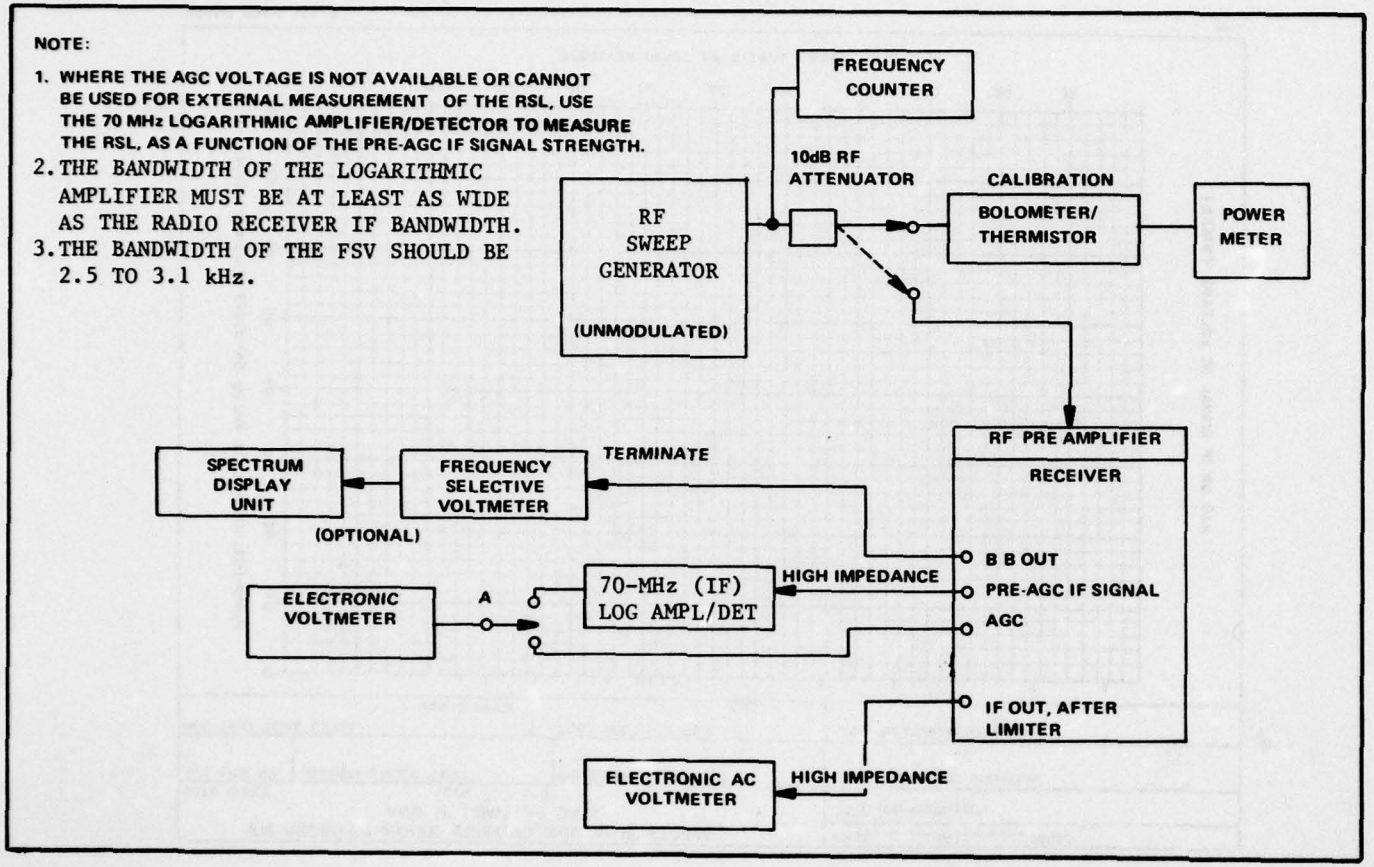


Figure 27-2. Receiver noise quieting test setup.

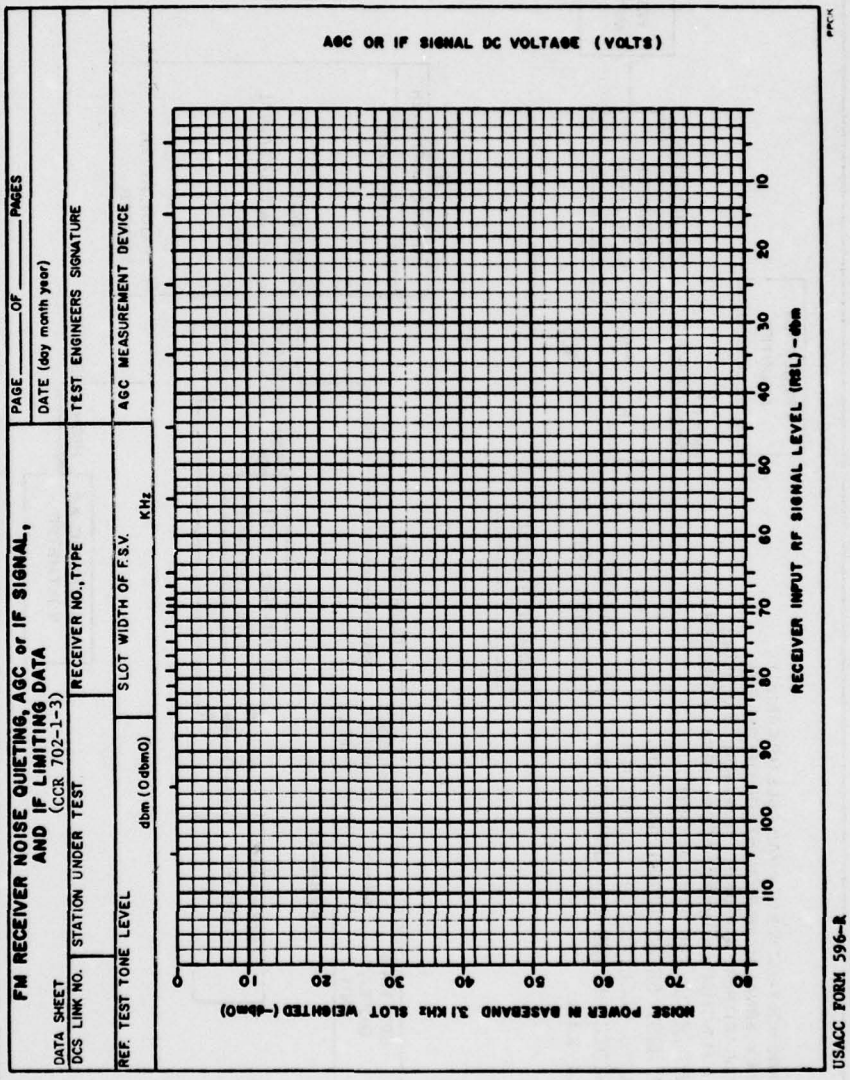
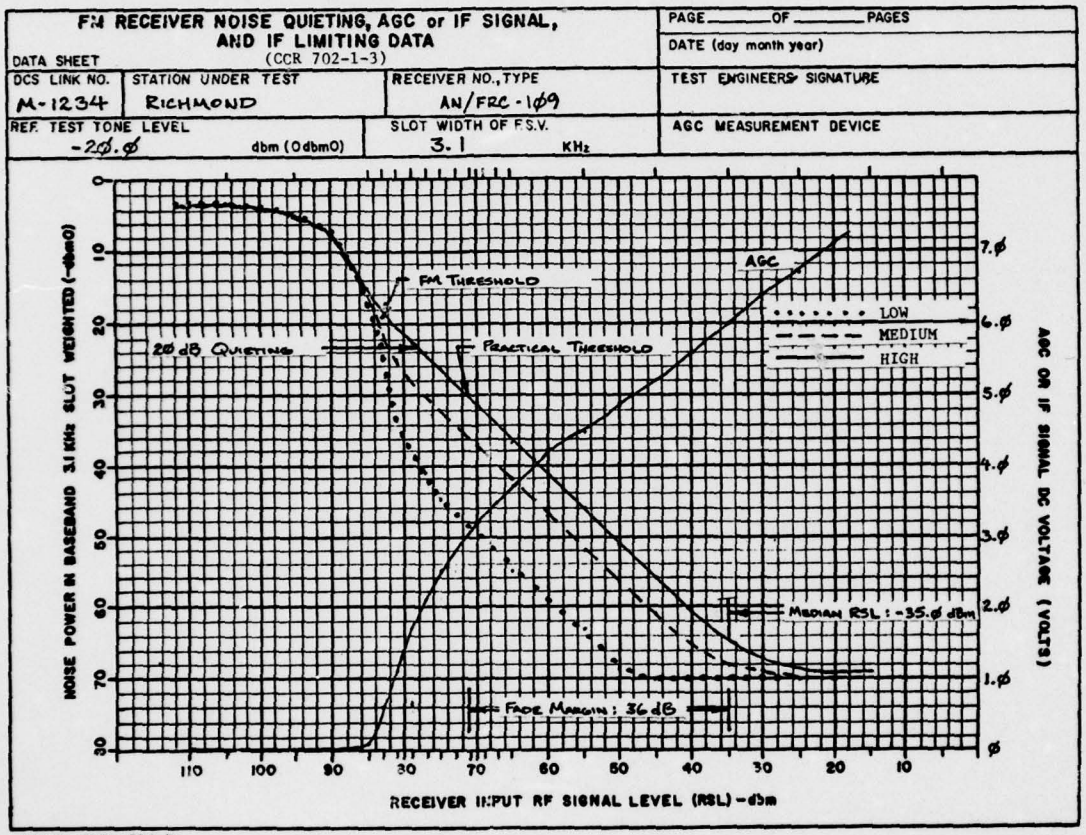


Figure 27-3. Receiver noise quieting profile data sheet.



USACC FORM 596-R
1 JUL 78

Figure 27-4. Typical receiver noise quieting curve (FM radio).

CHAPTER 28

RECEIVER TIMING OUTPUT (DT-225)

28-1. GENERAL.

a. The purpose of this test is to measure the recovered receive timing at the output connector of the receiver. The recovered MBS clock may also be measured at the clock recovery test point on the demodulator.

b. This test is not applicable to the AN/FRC-162.

c. The recovered clock rate will depend on the data rate for which the radio set is configured.

d. This test may be performed on contractor EF&I systems to assure that they conform to contract specifications or other applicable documents. It may also be performed by installer or quality assurance personnel during test and acceptance activities as directed.

28-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) Provisions shall be included in the radio to provide recovered receive timing as an output through a connector.

(2) The recovered receive timing output at the MBS shall be at the MBS rates shown in table 15-2.

(3) The radio shall provide polar square wave MBS and SCBS timing outputs phase-locked to the radio transmit clock at the MBS and SCBS rates (fig. 15-1).

(4) The output impedance shall be 78 ohms ±10 percent (balanced). The capacitive shunt shall be less than 15 pF to ground.

(5) The open circuit voltage at the interface shall be ±4 VPP ±10 percent and when terminated in its characteristic impedance, it shall be ±2 VPP ±10 percent.

(6) The output rise and fall times T_r and T_f, in figure 15-2, when measured between the 10- and 90-percent points shall be greater than 4 nsec and less than 12 nsec for data rates greater than 2 mb/s and shall be less than 100 nsec for data rates 2 mb/s or less.

(7) The trailing edge positive-to-negative transition, of the output timing signal, shall occur within ±4 percent of the center of the nominal unit interval of the NRZ data signal as shown in figure 15-3.

(8) The output timing signals shall not have more than ±4 percent jitter (peak-to-peak) of the nominal data unit interval.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

28-3. TEST EQUIPMENT REQUIRED.

a. Pattern generator or digital multiplex.

b. Frequency counter.

c. Phase jitter meter.

d. Oscilloscope camera.

e. Impedance bridge.

f. Error detector.

g. Turnaround mixer and attenuators.

h. Oscilloscope.

28-4. TEST PROCEDURES.

a. Output Impedance.

(1) Connect the test equipment as shown in figure 28-1a and allow approximately 30 minutes for warmup and stabilization.

(2) Set the output frequency of the bridge to the center of the radio input rate as shown in table 15-2. As an example, if the radio is being tested for 12.9 mb/s, set the output frequency to approximately 6.4 MHz.

(3) Calibrate the bridge to read impedance in accordance with the manufacturer's instructions with the output terminated into a 78-ohm ±1-percent precision resistor.

(4) After the bridge has been initially calibrated, slowly adjust the frequency from 500 kHz to the highest data rate for which the radio is designed. Observe that the calibration remains unchanged over the frequency range.

(5) Initially set the bridge to half of the designed data rate of the radio and connect it to the receiver recovered timing connector.

(6) Remove the receiver recovered clock module or terminate the clock output impedance.

(7) Measure and record the impedance at the connector output at the frequencies shown in table 15-2.

(8) Change the bridge to read capacitance and measure and record the shunt capacitance at the frequencies shown in table 15-2.

(9) Record the test results on figure 28-2 (USACC Form 638-R).

b. Output Voltage Level.

(1) Connect the test equipment as shown in figure 28-3.

(2) Connect the oscilloscope to the receiver recovered output timing connector and measure the open circuit voltage. The measured output should be ±4 VPP ±10 percent.

(3) Terminate the connector output into a 78-ohm, 1-percent resistor and measure the terminated voltage with the oscilloscope. The measured voltage should be ±2 VPP ±10 percent.

(4) Record the results on figure 28-2 (USACC Form 638-R).

c. Timing Frequency.

(1) Use an oscilloscope or a frequency counter to measure the timing frequency.

(2) Connect the frequency counter to the receiver recovered timing connector and ensure that the counter is in the high impedance position. If using an oscilloscope, calibrate the oscilloscope in accordance with the manufacturer's instruction for the frequency to be measured.

(3) Connect the equipment as shown in figure 28-3. Measure and record the recovered clock output frequency.

d. Timing Output. The radio should provide polar square wave MBS and SCBS timing outputs phase-locked to the radio transmit clock at the MBS and SCBS rates of table 15-2.

(1) Connect the equipment as shown in figure 28-3 and compare the recovered timing output with the transmitter clock output. Record the results on the data sheet.

(2) Measure the rise and fall times at the recovered clock output and compare the measured data to that shown in figure 15-2. Record the results on the data sheet.

(3) For a permanent record, photograph the test results and mount the photographs on figure 5-2 (DD Form 2093).

(4) Verify that the trailing edge, positive-to-negative transitions of the recovered timing signal, occur as shown in figure 15-3. Record the results on the data sheet.

e. Output Jitter.

(1) *Phase jitter meter method.* The jitter at the recovered timing connector can be measured with an oscilloscope or jitter meter having the same data rate and signal characteristics of the radio set timing output.

(a) Connect the jitter meter for the data rate at which the radio set has been designed to operate and connect the meter input to the receiver recovered timing connector.

(b) If the jitter meter input impedance does not match the timing connector output, use a matching device or insert a 10-dB attenuator in front of the meter input to minimize slight impedance variations.

(c) Set up the phase jitter meter in accordance with the manufacturer's instructions and set the jitter meter timer for 15 minutes.

(d) Measure and record any timing jitter and phase hits on the data sheet.

(2) *Oscilloscope method.*

(a) Connect the oscilloscope to the recovered receive timing output connector as shown in figure 28-3.

(b) The radio set may be looped at RF or IF. If looped at RF, insert an attenuator and a turnaround mixer between the transmitter output and the receiver input as shown in figure 28-3. The turnaround mixer may be omitted if the transmitter and receiver are tuned to the same frequency.

(c) If this test is being performed with the MBS and SCBS loaded, set the pattern generator or digital multiplex to the specified bit rate for the equipment under test.

(d) Connect input A of the oscilloscope to the recovered timing connector and adjust the oscilloscope for one complete timing transition which begins at the 0-degree point.

(e) Connect channel B of the oscilloscope to the transmit timing clock or to a highly stable oscillator.

(f) Adjust the oscilloscope A and B inputs for equal amplitudes of the two signals.

(g) Set the vertical position and amplitude controls of the oscilloscope so that the 0-, 180-, and 360-degree points are exactly on the center graticule. The phase jitter will appear as a smear of the zero crossing of the curve. The amount of smear, in units of degrees on the graticule, is a measure of the peak-to-peak phase jitter.

(h) Turn the X10 horizontal multiplier on. Peak-to-peak phase jitter can now be read on the center horizontal graticule as 3.6 degrees per large division on the graticule. In the event a X10 horizontal multiplier is not available on the oscilloscope, adjust the sweep speed of the oscilloscope to 10 µsec per division. This will provide the same display as when using the X10 multiplier.

(i) To provide easier and more accurate reading of the peak-to-peak jitter, increase the vertical oscilloscope sensitivity. At extremely sensitive settings, the vertical position of the display may move. Corrections for this must be made before the amount of jitter can be accurately determined.

(j) Record the amount of measured jitter on figure 28-2 (USACC Form 638-R).

28-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable elements of the data sheets and compare the measured results with the applicable specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified performance criteria, notify the responsible activity of required corrective actions.

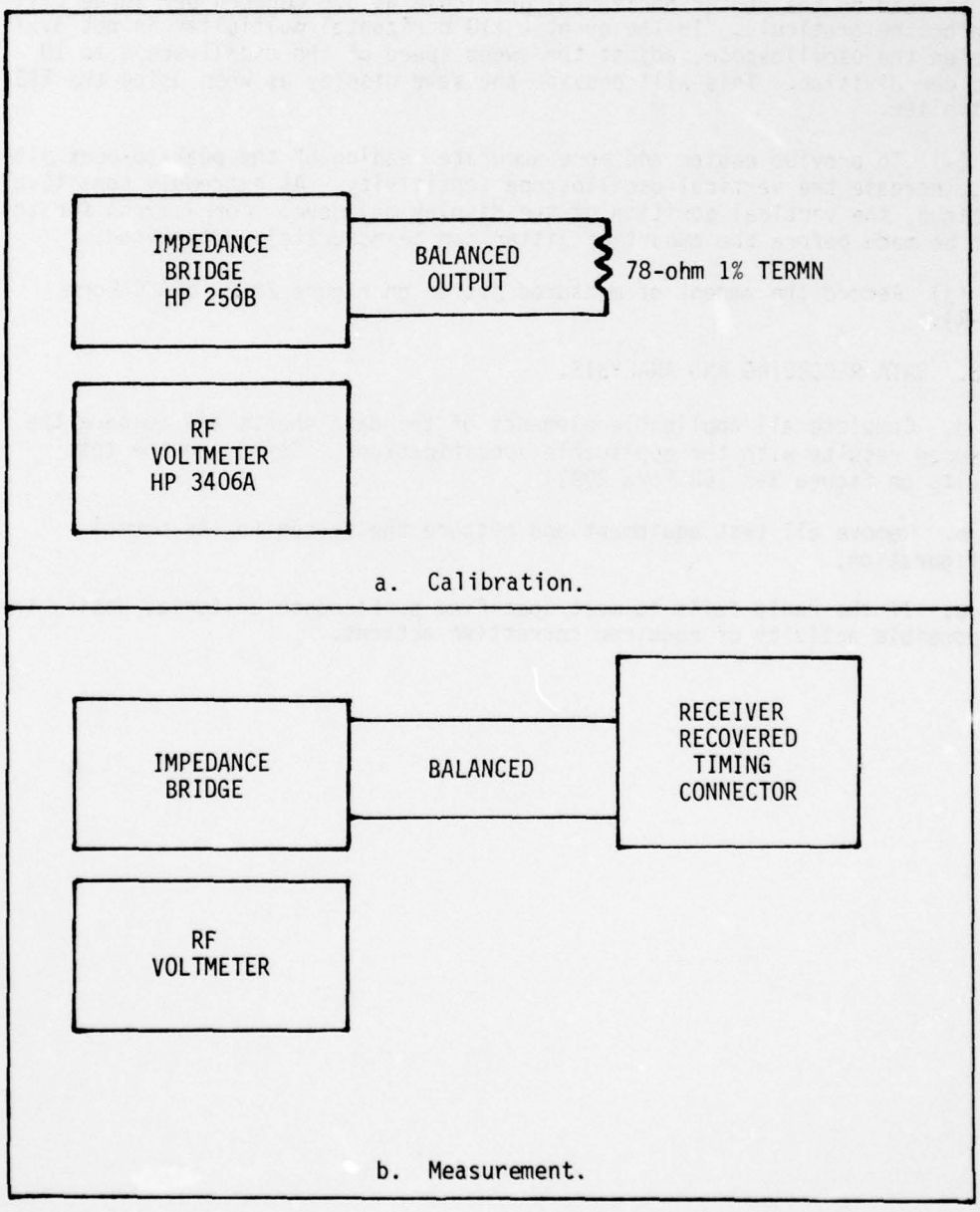
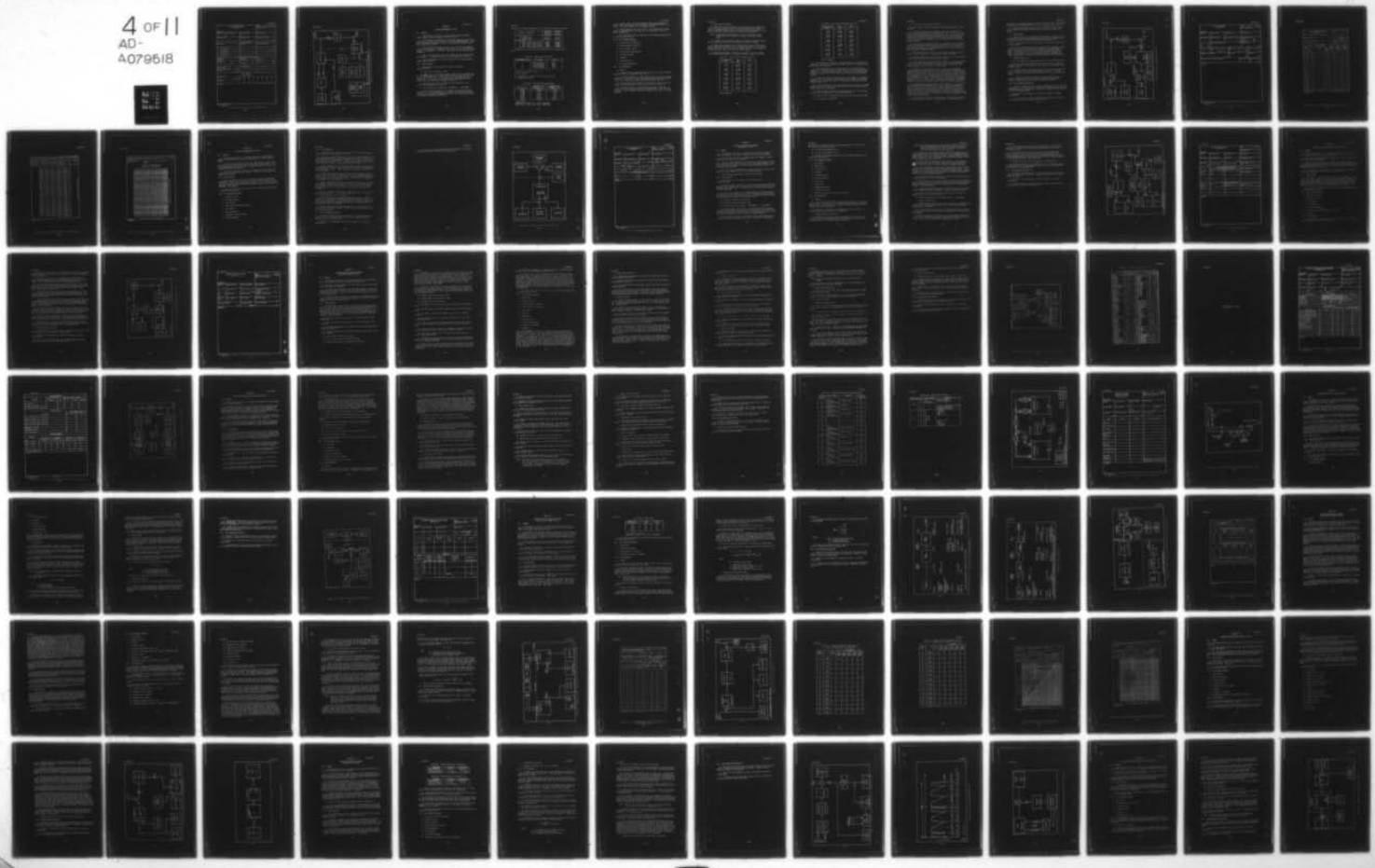
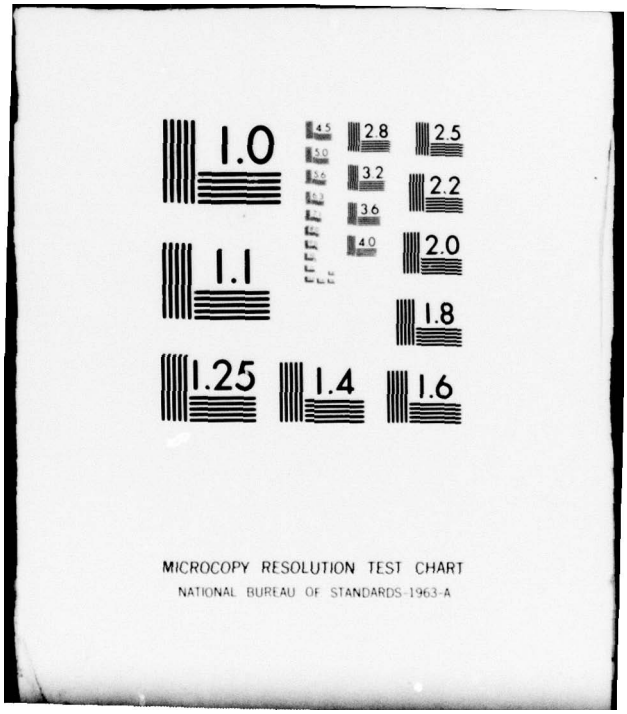


Figure 28-1. Receiver recovered timing calibration and test setup.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

4 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

RECOVERED RECEIVE TIMING (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.		RCVR SER NO.	DESIGN BIT RATE mb/s
OUTPUT IMPEDANCE			
DESIGN SPEC Ω		MEASURED Ω	CAPACITANCE SHUNT pF
3.232 mb/s			
6.464 mb/s			
9.696 mb/s			
12.928 mb/s			
OUTPUT VOLTAGE AND CLOCK FREQUENCY			
DESIGN SPEC OPEN CIRCUIT VPP		DESIGN SPEC TERMINATED VPP	DESIGN SPEC CLOCK MHz
MEASURED VPP		MEASURED VPP	MEASURED MHz
CLOCK OUTPUT			
DESIGN SPEC RISE & FALL TIMES nsec		TRAILING EDGE ±%	OUTPUT JITTER ±%
MEASURED nsec		±%	p-p ° ±%
PHASE HITS (IN 15 MINUTES)			
DESIGN SPEC NO. HITS			
MEASURED			
COMMENTS			

USACC FORM 638-R
1 MAY 79

Figure 28-2. Recovered receive timing data sheet.

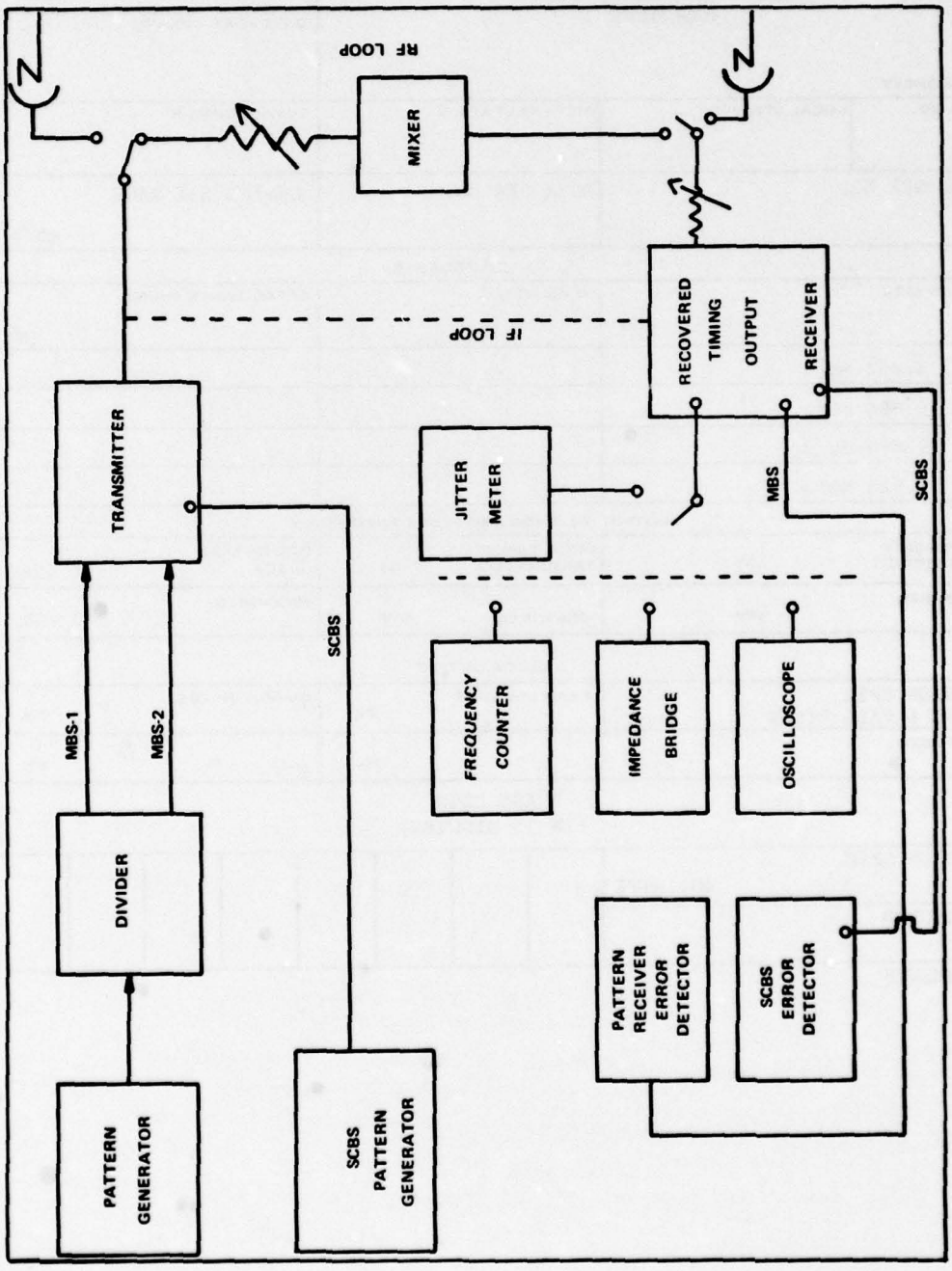


Figure 28-3. Output voltage level test setup.

CHAPTER 29

RECEIVER PERFORMANCE (DT-226)

29-1. GENERAL.

a. The purpose of this test is to measure small signal performance, dynamic range, and BER performance floor of the radio.

b. This test may be performed on contractor EF&I systems to assure that they conform to contract specifications or other applicable documents. It may also be performed by installer or quality assurance personnel during onsite test activities as directed.

c. This test may be performed in an RF loop or over the link; however, the specified performance in paragraph 29-2c, below, is for an RF loop configuration. If performed on a loop basis, the RSL and BER data should be time correlated.

d. Some of the data sheets used in this chapter are also used for other test sequences. Consequently, some minor onsite changes may be required.

e. Repeat the procedures outlined in paragraph 29-4 for other radios or systems to be evaluated.

29-2. SPECIFICATIONS.

a. The following criteria applies to receiver performance. (MIL-STD-188-322)

(1) *Small signal performance.* None.

(2) *Dynamic range.* The receiver dynamic range shall be a minimum of 50 dB. For a stable RSL that is 20 dB greater than the minimum stable RSL providing a BER of 5×10^{-9} bits, the receiver shall provide a BER less than 1×10^{-10} bits. The receiver, in the configuration to be employed, shall provide the radio link performance shown in table 29-1.

(3) *BER performance floor.* The BER shall not exceed 1×10^{-10} bits for the performance shown in table 29-1.

b. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) *Small signal performance.* As a minimum, the digital radio shall provide the small signal performance, as measured at the RF interface point (table 29-2), at the specified performance levels, for the MBS rate/transmitter bandwidth combinations (table 29-3).

Table 29-1. Performance Parameters for LOS Digital Microwave Transmission

AN/FRC-( ) PARAMETER	REFERENCE SUBSYSTEM PARAMETER	REFERENCE LINK* PARAMETER
Bit error rate		
a. Below 10 GHz	60×10^{-9}	5×10^{-9}
b. Above 10 GHz	48×10^{-9}	2×10^{-9}
Availability		
a. BER = 5×10^{-9} below 10 GHz	0.9994	0.00005
b. BER = 1×10^{-2} below 10 GHz	0.9997	0.99998
c. BER = 2×10^{-9} above 10 GHz	0.9992	0.99998
d. BER = 1×10^{-2} above 10 GHz	0.9995	0.99998

*Reference link = one full duplex radio path with one radio at each end.

Table 29-2. Small Signal Performance

PERFORMANCE LEVEL	RSL (dBm)*	BER**
I	$-164+10\log_{10}R+NF$	5×10^{-2}
I	$-157+10\log_{10}R+NF$	5×10^{-9}
II	$-158+10\log_{10}R+NF$	5×10^{-2}
II	$-151+10\log_{10}R+NF$	5×10^{-9}

*10 dB based on specification.
**With randomizer.

NF = Receiver noise figure; specification value 10 dB.
R = Aggregate bit rate.

Table 29-3. Transmitted Bandwidths (MHz)

TOTAL MBS RATE (mb/s)	BANDWIDTH FOR PERFORMANCE LEVEL I* (MHz)	BANDWIDTH FOR PERFORMANCE LEVEL II* (MHz)
3.232	3.5**	NA
6.464	7.0	3.5**
9.696	10.5***	7.0
12.928	14.0	7.0
19.392	20.0***	10.5***
25.856	20.0***	14.0

*See table 29- .
**Applicable to band 1 only (4400 to 5000 MHz).
***Applicable to band 2 only (7125 to 8400 MHz).

(2) *Dynamic range.* The receiver dynamic range is the difference in signal levels in dB between the RSL determined in paragraph 29-2a(2) for a $5x10^{-9}$. The dynamic range shall be a minimum of 50 dB.

(3) *BER performance floor.* For an RSL of 20 dB above the RSL's determined in paragraph 29-2a(2), the BER shall not exceed $1x10^{-10}$ bits 95 percent of the time.

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

29-3. TEST EQUIPMENT REQUIRED.

a. Pattern generator, MBS rate.

b. Pattern generator, SCBS rate.

c. Error recorder, digital.

d. Error detector, MBS and SCBS.

e. Stripchart recorder.

f. Voltmeter.

g. Turnaround mixer.

h. RF variable attenuators.

29-4. TEST PROCEDURES.

a. General.

(1) Connect the test equipment as shown in figure 29-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Set the MBS generator or digital multiplex for the bit rate at which the radio is to be tested. Connect the pattern generator output to the MBS input of the transmitter and adjust the generator output for 1 VPP.

(3) Set the SCBS pattern generator to 192 kb/s at a level of 1 VPP and connect the generator output to the transmitter SCBS input terminal.

(4) Place the radio set in an RF loopback as shown in figure 29-1, if testing to the specifications contained in paragraph 29-2c. Omit the turnaround mixer if the transmitter and receiver under test are tuned to the same frequency.

b. Small Signal Performance.

(1) Adjust the variable attenuator (AT-1) to provide a safe operating level to the turnaround mixer and initially adjust the RSL for -30 dBm. If used, the turnaround mixer or IF must be tuned to the center frequency of the radio as indicated by maximum AGC or IF voltage on the voltmeter.

NOTE: DT-224 should be performed prior to this test so that a calibrated AGC versus RSL graph is available to establish the RSL input.

(2) Transmit data on the MBS and SCBS for 15 minutes and observe that the errors recorded on the receive error detector are $1x10^{-10}$ or better.

(3) Adjust the attenuator (AT-2) to the RSL value shown in table 29-4 or 29-5 as applicable and transmit data at the specified bit rate for 15 minutes. Note and record any errors on figure 29-2 (USACC Form 639-R), and compute the average error rate. Record this value on the data sheet.

(4) Repeat subparagraphs (1) through (3), above, for each of the RSL's and for those data rates that are applicable as shown in table 29-4 or 29-5.

Table 29-4. Small Signal Performance (Level I)

TOTAL MBS RATE (mb/s)	RSL (dBm)	BER*
3.232	-88.90	$5x10^{-2}$
3.232	-81.90	$5x10^{-9}$
6.464	-85.89	$5x10^{-2}$
6.464	-78.89	$5x10^{-9}$
9.696	-84.13	$5x10^{-2}$
9.696	-77.13	$5x10^{-9}$
12.928	-82.88	$5x10^{-2}$
12.928	-75.88	$5x10^{-9}$
19.392	-81.12	$5x10^{-2}$
19.392	-74.12	$5x10^{-9}$
25.856	-79.87	$5x10^{-2}$
25.856	-72.87	$5x10^{-9}$

*With randomizer.

Table 29-5. Small Signal Performance (Level II)

TOTAL MBS RATE (mb/s)	RSL (dBm)	BER*
3.232	-82.90	$5x10^{-2}$
3.232	-75.90	$5x10^{-9}$
6.464	-79.89	$5x10^{-2}$
6.464	-72.89	$5x10^{-9}$
9.696	-78.13	$5x10^{-2}$
9.696	-71.13	$5x10^{-9}$
12.928	-76.88	$5x10^{-2}$
12.928	-69.88	$5x10^{-9}$
19.392	-75.12	$5x10^{-2}$
19.392	-68.12	$5x10^{-9}$
25.856	-73.87	$5x10^{-2}$
25.856	-66.87	$5x10^{-9}$

*With randomizer.

c. *Link Recording.* If the test is being performed on a link basis as a comparison to the military standard requirements contained in paragraph 29-2a, perform the following tests.

(1) Calibrate the stripchart recorder according to the manufacturer's instructions. Calibration should cover the AGC or IF voltage range from fully saturated to a level below a BER of 5x10-2. The AGC or IF versus RSL graph plotted during DT-224 (fig. 27-4) may be used in calibrating the stripchart recorder.

(2) Adjust the stripchart recorder speed so that bunching or smearing of the data is avoided; however, the speed required will depend on link fading characteristics. For an LOS link, a 5-millimeter-per-minute speed should be adequate in most cases.

(3) At the receive end of the link, connect the error recorder to the BER detector test set to record bit and block errors as well as synchronize parameters affecting link performance.

(4) Before, during, and after the recording period, mark the stripchart and data error recording with the following information:

(a) Recording site, distant station, date and time, and recording number.

(b) Link number, if applicable.

(c) Calibration of the recorded parameter.

(d) Chart speed, including all changes of chart speed during the recording period.

(5) During the stripchart recording time, note on the stripchart all points of interest, abnormalities, discontinuities, etc. This will later aid in the analysis of the recorded data. Additionally, periodically record the time on the stripchart and the digital printout to facilitate analyzing the recorded data. The time indicated on the stripchart recording of the RSL will be correlated with time markings of bit and block errors on the digital recorder printout.

(6) Transmit data on the MBS and SCBS for the required recording period. This period will be determined by the team chief; however, 24 hours of continuous recording should be the minimum recording period. At the receive end, record the test results at the normal operating RSL of the link. Record this RSL on figure 29-2 (USACC Form 639-R).

(7) On relatively stable links, place an attenuator before the receiver input as shown in figure 29-1, to obtain a plot of RSL versus BER.

d. Recording Summary. From the recording, determine the long-term median and the cumulative distribution for the RSL as follows:

(1) Divide the recording into equal time intervals. The length of these intervals will depend on the degree of variation in the recorded parameter. If the variation is relatively fast, a shorter interval may be used. Normally, the interval will range from 5 to 20 minutes.

(2) Determine the value of each interval. There are two generally accepted methods for determining this value. One method is to determine the median for the short interval by use of a stretched string, or other means to estimate the median value. The other method is to sample the interval, taking the instantaneous value of the parameter at each equal time interval. Either of these methods will result in approximately the same long-term median; however, there will be a difference in the cumulative distribution. The sample method will result in a wider range of values than the interval median method. Therefore, the method used must be shown on figure 29-2 (USACC Form 639-R).

(3) Determine the long-term median for each parameter. Figures 29-3 (DD Form 2098) and 29-4 (DD Form 2099) will be used in reducing the recorded data. After the value for each interval has been determined, arrange the values in ascending or descending order. Make a stroke for each interval at each of the values. Count the total number of intervals (or strokes) and divide this total by 2. Then, starting at either the top or the bottom, count the number of strokes equal to this quotient. The value corresponding to that point is the long-term median.

(4) Determine the distribution and cumulative distribution by calculating the values indicated on figures 29-3 (DD Form 2098). Plot the cumulative

distribution for the BER parameter on figure 29-4 (DD Form 2099). Plot the RSL distribution on figure 29-5 (DCA Form T1-14) if a separate plot is required.

(5) Compare the recorded results with the requirements shown in table 29-1 and enter the percentage of availability on figure 29-2 (USACC Form 639-R).

e. Dynamic Range.

(1) Connect the radio in a back-to-back loop as shown in figure 29-1. If this part of the test is being performed on a link basis, it should be accomplished as part of the recording test described in paragraph 29-4c.

(2) At the transmit end, transmit data with the data test set at the bit rate of the radio.

(3) At the receive end, adjust AT-2 to provide an RSL equating to a BER of $5x10^{-9}$ as shown in table 29-4 or 29-5, depending on the performance level of the radio under test. Record this RSL on figure 29-2 (USACC Form 639-R). Slowly adjust AT-2 until the received BER becomes degraded from $5x10^{-9}$. The difference in the two RSL readings represents the dynamic range of the receiver. Record this value on figure 29-2 (USACC Form 639-R).

f. BER Performance Floor.

(1) At the transmit end, continue to send data at the specified bit rate.

(2) At the receive end, adjust AT-2 for an RSL of $5x10^{-9}$. Adjust the attenuator to provide a 20-dB increase in RSL above that value determined for a BER of $5x10^{-9}$.

(3) Transmit data for 15 minutes and note, at the receive end, that the error rate does not exceed $1x10^{-10}$ 95 percent of the time. If a longer period is required, follow the recording procedures as outlined in paragraph 29-4d.

(4) If the 20-dB increase in RSL does not provide an error rate of $1x10^{-10}$ or better, adjust AT-2 to the RSL at which this value can be obtained. Record this value on figure 29-2 (USACC Form 639-R).

29-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for validity and compliance with the specified requirements. If additional space is needed on the data sheets for recording pertinent comments, use figure 3-7 (DD Form 2091). Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet the specified requirements, notify the responsible activity of required corrective actions.

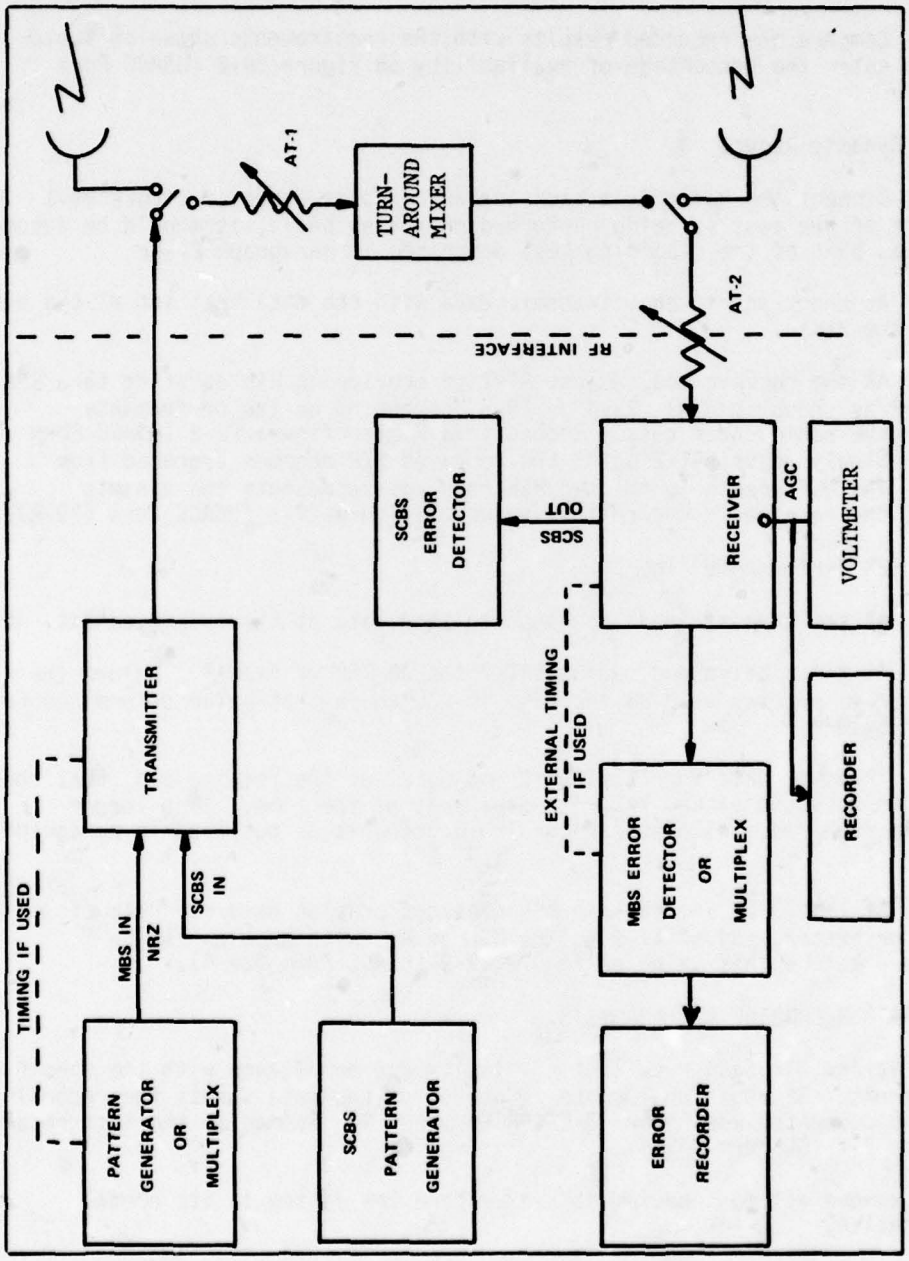


Figure 29-1. Receiver performance test setup.

RECEIVER PERFORMANCE (CCR 702-1-3)			PAGE OF PAGES
DATA SHEET			DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	AGGREGATE BIT RATE mb/s	PERFORMANCE LEVEL LEVEL I ☐ LEVEL II ☐
LINK ☐ LOOP ☐	DATA REDUCTION METHOD		OPERATING RSL dBm

BER					
5×10^{-2}	RSL dBm	5×10^{-9}	RSL dBm	1×10^{-10}	RSL dBm
RECEIVER DYNAMIC RANGE dB		BER AT 95% RSL dBm		MEDIAN RSL dBm	
AVAILABILITY: % TIME ORDINATE EXCEEDED			RECORDING NO.	TOTAL RECORDING TIME min	
COMMENTS					

USACC FORM 639-R
1 MAY 79

Figure 29-2. Receiver performance data sheet.

CUMULATIVE PROBABILITY DISTRIBUTION STROKE CHART

PAGE ____ OF ____ PAGES

DATE

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

TEST NO.	TEST TITLE	RUN/RECORDING TIME START Z	STOP Z

SG	GP	CH	EQUIPMENT	METHOD ☐ SAMPLE ☐ MEDIAN	RUN/RECORD NOS.

RUN AVERAGE ERROR RATE %	SAMPLE VALUE UNITS ____ ____	NUMBER OF RUNS/SAMPLES EACH HAVING THE INDICATED AVERAGE: STROKES	TOTAL NO. OF STROKES	TOTAL TIME RUN AVG./ SAMPLES WERE AT THE INDICATED VALUE (min.)	PERCENT OF TIME RUN AVG./ SAMPLES WERE AT THE INDICATED VALUE	CUMULATIVE PERCENT OF TIME RUN AVG./ SAMPLES WERE AT THE INDICATED VALUE
10.0						
7.0						
3.0						
1.0						
0.7						
0.3						
0.1						
0.07						
0.03						
0.01						
0.007						
0.003						
00.001						
0.0007						
0.0003						
00.0001						
0.00007						
0.00003						

TOTAL NO. OF RUNS/SAMPLES	TOTAL TIME MIN.	LONG TERM MEDIAN OF AVG.

DD FORM 1 SEP 77 2098

Figure 29-3. Cumulative probability distribution stroke chart.

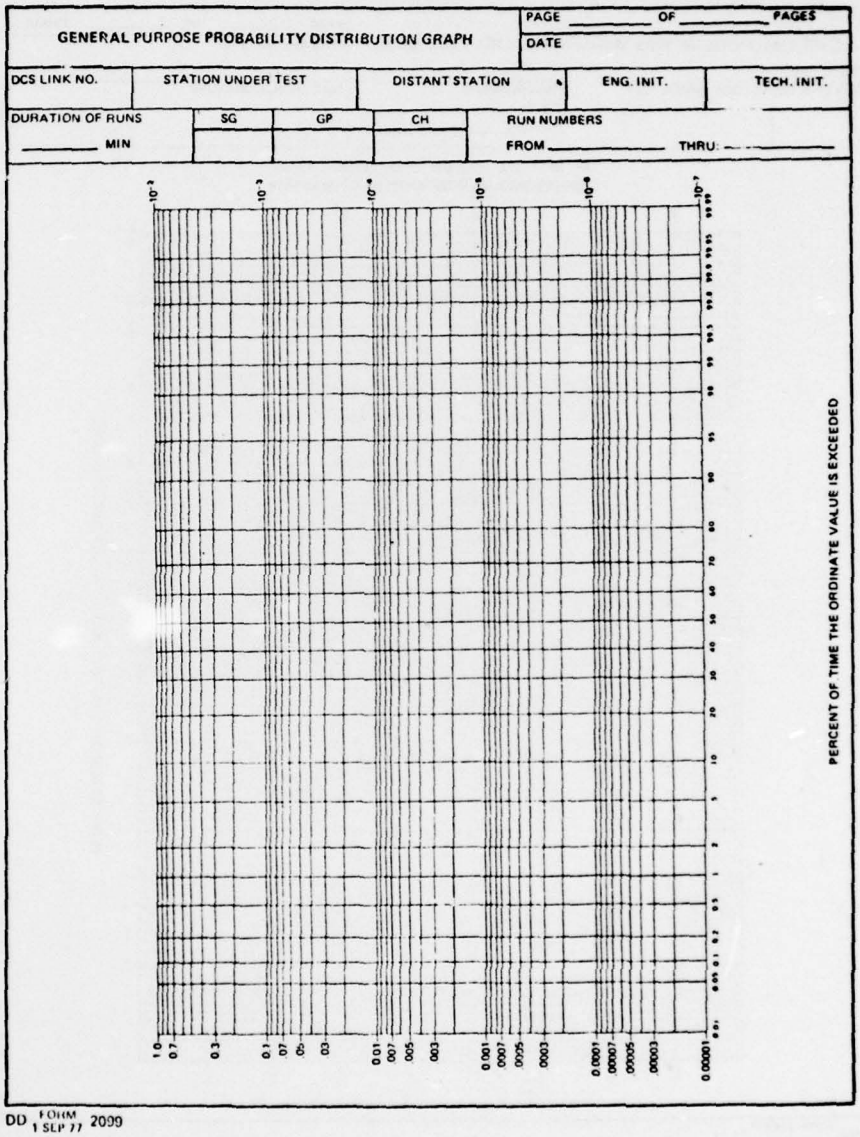


Figure 29-4. General purpose probability distribution graph.

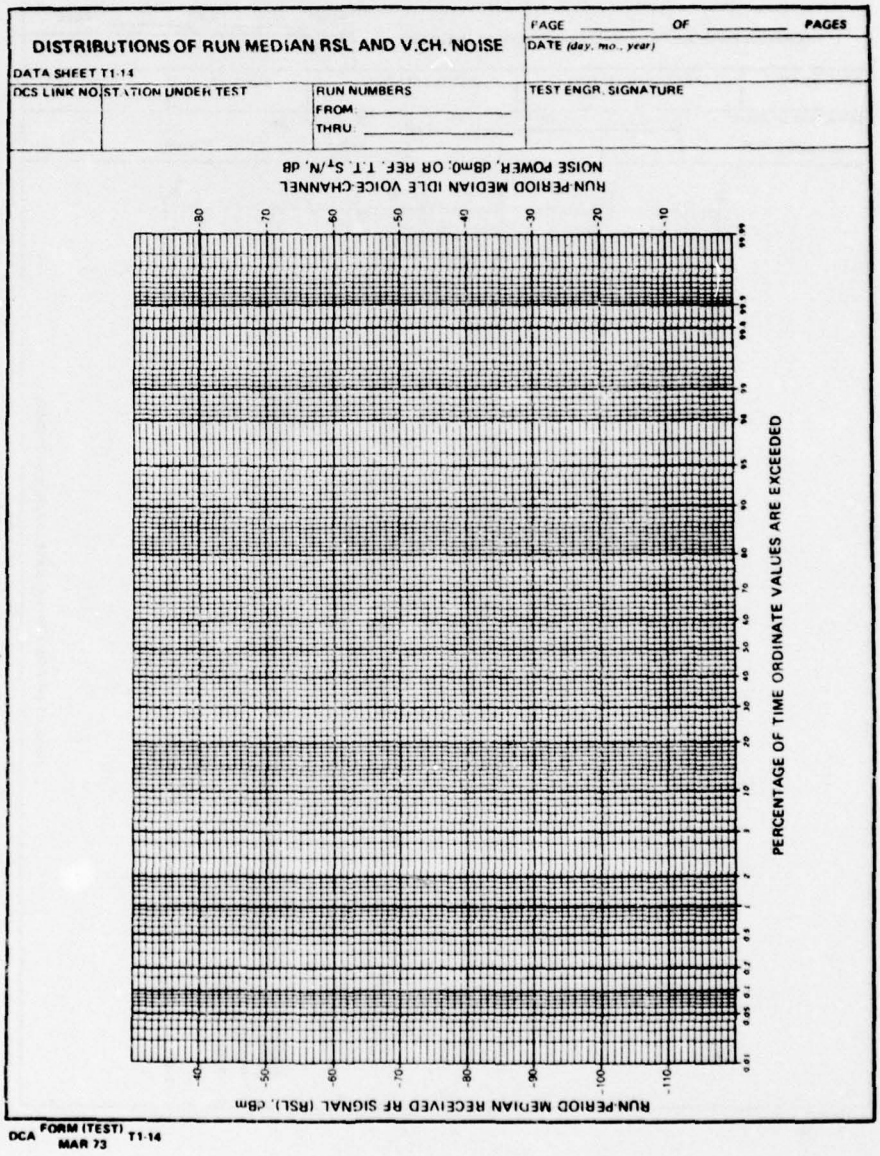


Figure 29-5. Distributions of run median RSL and V.CH. noise.

CHAPTER 30

RF RECEIVER INTERMODULATION (DT-227)

30-1. GENERAL.

a. The purpose of this test is to measure the 3d order intermodulation products in the IF amplifier with equal signals applied at the RF interface point.

b. This test may be performed on contractor EF&I systems to assure that they conform to contract specifications or other applicable documents. It may also be performed by installer or quality assurance personnel during test and acceptance activities as directed.

c. This test and the specifications in paragraph 30-2, below, apply primarily to the fully digitized radio; however, it may also be performed on the AN/FRC-162 as directed.

30-2. SPECIFICATIONS.

a. With any two equal level signals outside the authorized bandwidth of the AN/FRC-( ) applied to the receiver RF interface point at a level of -40 dBm, the level of 3d order intermodulation products in the IF shall not exceed the signal level that would result from the application of a single inband -90 dBm signal. (CCC-74049)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

30-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. RF sweep generator.

c. Power splitter.

d. Power meter with thermistor mount.

e. RF voltmeter.

f. Spectrum analyzer.

g. Waveguide to coaxial adapter.

h. Digital voltmeter.

30-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 30-1 and allow approximately 30 minutes for warmup and stabilization.

b. Record the authorized bandwidth on figure 30-2 (USACC Form 640-R). The authorized bandwidth will be based on the data rate for which the radio has been configured. The bandwidths for authorized data rates are shown in table 29-3 for performance levels I and II. Record the performance level and data rate at which the receiver is being tested on the data sheet.

c. Connect generator 1 or 2 to the power meter and set the generator output frequency to the center frequency of the receiver under test as measured with the frequency counter. Adjust the generator output for -90 dBm as read on the power meter.

d. Connect the generator output to the receiver RF interface point as shown in figure 30-1. With the spectrum analyzer or RF voltmeter, measure and record the IF signal level on the data sheet. Also measure and record the AGC or IF voltage. This establishes the reference level to be used to determine if the receiver meets specifications.

e. Adjust the generator frequency to the low and high ends of the authorized bandwidth. Measure and record the IF signal level and the AGC voltage. As an example, if the authorized bandwidth is 14 MHz, the generator would first be adjusted to F_C - 7 MHz and then to F_C + 7 MHz of the authorized frequency.

f. Adjust the output frequency of both generators to a frequency outside the authorized bandwidth. The frequency of generator 1 should be adjusted to F_C + 8 MHz and generator 2 to F_C - 8 MHz.

g. With both generators connected through a power splitter, adjust the output level of each generator (equally) to provide a composite -40 dBm signal as read on the power meter. The -40 dBm signal must include any cable loss or loss through a coaxial to waveguide transition when the composite signal is applied to the receiver RF interface.

h. Measure and record the level of any 3d order intermodulation products as observed on the spectrum analyzer. Record the level of any 3d order products on the data sheet.

30-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for accuracy and validity, and compare the measured results with the applicable specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the receiver to its normal configuration.

c. If the radio fails to meet the specified performance, notify the responsible activity of required corrective actions.

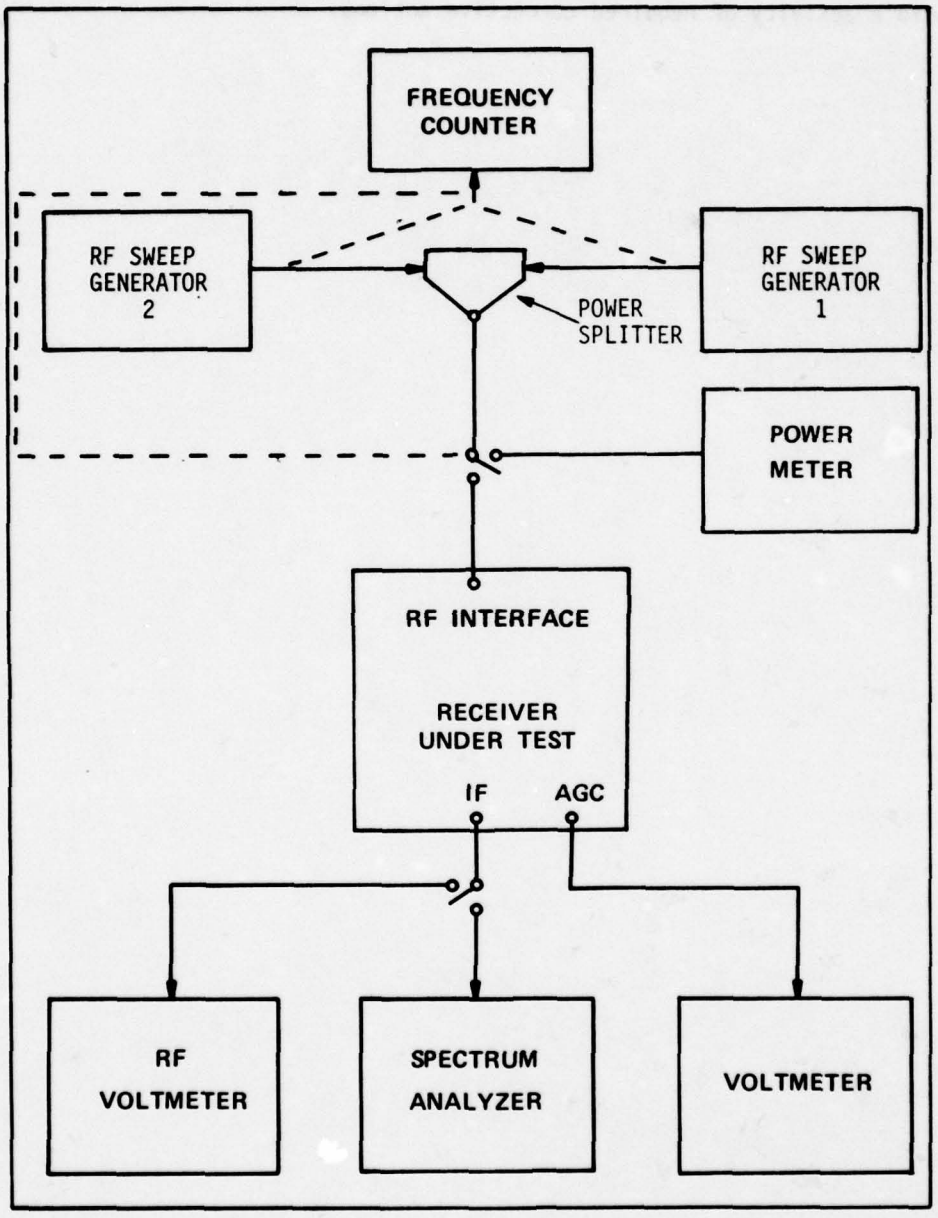


Figure 30-1. RF receiver intermodulation test setup.

RECEIVER INTERMODULATION (CCR 702-1-3)			PAGE OF PAGES
DATA SHEET			DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
RCVR SER NO.	AUTH BANDWIDTH MHz	DATA RATE mb/s	PERFORMANCE LEVEL LEVEL I ☐ LEVEL II ☐
ASGD FREQ MHz	IF SIGNAL AT -90 dBm INPUT VOLTS _____	_____ dBm	AGC VOLTS V DC
F_c +_____ MHz		F_c -_____ MHz	
dBm	VOLTS	dBm	VOLTS
INTERMODULATION PRODUCTS			
FREQ MHz		dBm	VOLTS
FREQ MHz		dBm	VOLTS
COMMENTS			

USACC FORM 640-R
1 MAY 79

Figure 30-2. Receiver intermodulation data sheet.

CHAPTER 31

RF RECEIVER ADJACENT AND COCHANNEL INTERFERENCE (DT-228)

31-1. GENERAL.

a. The purpose of this test is to measure and determine the adjacent channel and cochannel interference characteristics of the radio receiver.

b. This test does not apply to the AN/FRC-162 radio; however, it may be performed on this type radio, if required.

c. This test may be performed on contractor EF&I systems to ensure that they conform to contract specifications or other applicable documents. It may also be performed by installer or quality assurance personnel during onsite test activities as directed.

d. This test may be performed on an RF loop or link basis; however, paragraph 31-2, below, applies only to an RF loop configuration.

e. This test may be performed in conjunction with DT-232.

31-2. SPECIFICATIONS.

a. The following criteria applies to the radio receiver. (MIL-STD-188-322)

(1) *Adjacent channel interference.* The receiver shall provide specified performance with adjacent channel interference of any type having a level with respect to the desired signal. Requirements above and below 10 GHz have not yet been established.

(2) *Cochannel interference.* As a design objective, the receiver shall provide specified performance with less than 2 dB degraded receiver threshold for interference of any type within the specified receiver passband having the following levels with respect to the desired signal of:

(a) -20 dB for frequencies below 10 GHz.

(b) -25 dB for frequencies above 10 GHz.

b. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) *Adjacent channel interference.* The receiver shall meet specified performance requirements with an interfering signal applied to the RF interface point, 50 dB above the desired signal, at a frequency separation of twice the authorized bandwidth or greater from the assigned frequency.

(2) *Cochannel interference.* The receiver shall provide specified performance with less than 2 dB degraded receiver threshold for interference of

any type within the specified receiver passband having the following levels with respect to the desired signal.

(a) -20 dB for performance level I.

(b) -25 dB for performance level II.

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

31-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. BER test set.

c. Turnaround mixer.

d. Voltmeter.

e. Frequency counter.

f. RF sweep generator.

g. Oscillator.

h. Noise source.

i. Waveguide attenuator.

j. Directional coupler.

k. Adapters, connectors, and cables as required.

31-4. TEST PROCEDURES.

a. General.

(1) Connect the test equipment in a back-to-back RF loop or link configuration as shown in figure 31-1. Allow approximately 30 minutes for warmup and stabilization. If the transmitter is tuned to the center frequency of the receiver, omit the turnaround mixer.

(2) Adjust AT-1 to provide a safe operating level into the mixer. The transmitter should be adjusted for full output power.

b. Adjacent Channel Interference.

(1) Adjust AT-2 to provide an RSL corresponding to a BER of 5×10^{-9} at the design data rate and bandwidth of the radio under test. The RSL can be obtained from one of the formulas shown in table 29-2.

NOTE: The receiver quieting test (DT-224) should precede this test so that a calibrated AGC voltage versus RSL graph is available to establish the effective RSL. Refer to table 10-2 for establishing the RSL based on the above equations.

(2) Transmit data on the MBS and SCBS input to the transmitter at the appropriate bit rate. The transmit input data can be provided by either a compatible BER test set or a digital multiplex. Adjust the BER test set or multiplex output for 1 VPP. Adjust the receive MBS and SCBS output levels for 1 VPP as measured with the oscilloscope.

(3) With the RSL corresponding to a BER of $5x10^{-9}$, transmit data for 15 minutes and observe at the receive end that the errors do not exceed $5x10^{-9}$. Record the number of errors on figure 31-2 (USACC Form 641-R).

(4) With the generator and power meter, establish an RF signal from the generator 50 dB above the RSL calculated above for a BER of $5x10^{-9}$. Tune the generator to a frequency twice the authorized bandwidth from the assigned frequency. If using a sweep signal, the limit of the sweep should be maintained at twice the authorized bandwidth.

(5) Connect the generator output to the receiver input, either through a directional coupler or a coaxial T-connector.

(6) At the transmit end, transmit data for 15 minutes while observing for errors at the receive end. The signal inserted from the generator should not degrade the BER performance ($5x10^{-9}$) from that determined in subparagraph (3) above. Record the results.

(a) Change the generator frequency to the opposite side of the assigned center frequency and repeat subparagraph (4) above. Record the results.

(b) Reduce the RSL to correspond to a BER of $5x10^{-2}$ and repeat subparagraph (6) above. Record the results.

(7) Repeat the procedure for performance level II, if applicable.

c. Cochannel interference.

(1) Connect the test equipment as shown in figure 31-1 and adjust AT-2 to provide an RSL corresponding to a BER of $5x10^{-9}$ as determined from paragraph 31-4b(1) or table 10-2.

(2) At the transmit end, send data on the MBS and SCBS for 15 minutes while at the receive end observe to ensure that the BER is within specified requirements.

(3) Adjust the generator frequency to the assigned center frequency of the receiver. Calibrate the generator output with the power meter to provide a level -20 dB from that established in subparagraph (1) above.

(4) With data being transmitted, connect the generator to the receiver input and, if required, externally modulate the generator with an audio or noise signal source.

(5) At the receive end, if errors are being received exceeding the $5x10^{-9}$, adjust AT-2 until a BER of $5x10^{-9}$ has been reestablished. The difference between the initial setting of the attenuator (before application of the interference) and the final setting with interference applied represents the interference threshold. Record this value.

(6) Repeat the test at an RSL corresponding to a BER of $5x10^{-2}$.

(7) Repeat the procedure for performance level II, if applicable, except the generator output in subparagraph (3) above should be set at -25 dB from that established in paragraph 31-4b(1).

31-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for completeness and accuracy. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

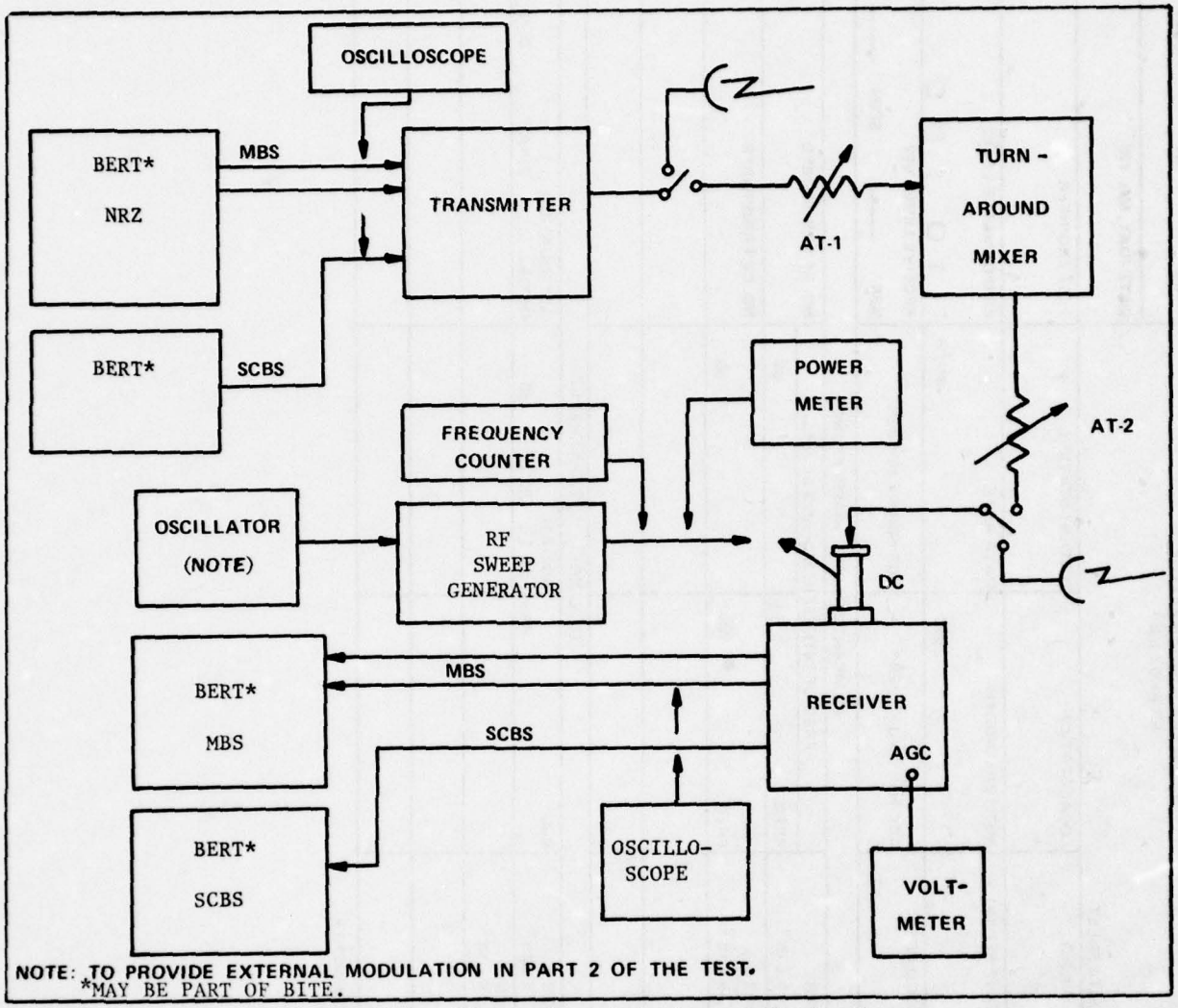


Figure 31-1. RF receiver interference test setup.

RF RECEIVER INTERFERENCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
RCVR SER NO.	AUTH BANDWIDTH MHz	DATA RATE mb/s	PERFORMANCE LEVEL I ☐ II ☐
ASGD FREQ MHz	AGC FOR 5 X 10^{-9} BER	AGC FOR 5 x 10^{-2} BER	RECEIVE LEVEL VPP MBS ____ SCBS ____
ADJACENT CHANNEL INTERFERENCE			
BER 5 x 10^{-9}	FREQ OF INTERFERENCE AND LEVEL FREQ MHz	dB	NO. OF ERRORS/BER
BER 5 x 10^{-2}	FREQ MHz	dB	NO. OF ERRORS/BER
COCHANNEL INTERFERENCE			
BER 5 x 10^{-9}	RSL dBm	ADJ RSL -20 ☐ -25 ☐ dB	ATTENUATION INITIAL ____ FINAL ___ DIFF_
BER 5 x 10^{-2}			
COMMENTS			

USACC FORM 641-R
1 MAY 79

Figure 31-2. RF receiver interference data sheet.

CHAPTER 32

RECEIVER CARRIER AND CLOCK RECOVERY (DT-229)

32-1. GENERAL.

a. The purpose of this test is to measure and record the carrier and clock recovery characteristics of the radio receiver.

b. This test is not applicable to the three-level, partial-response radio modified for digital transmission.

c. This test may be performed on contractor EF&I systems to ensure that they conform to contract specifications or other applicable documents. It may also be performed by installer or quality assurance personnel during test and acceptance activities as directed.

d. This test may also be performed on a link basis; however, the specifications in paragraph 32-2a, below, may not be applicable.

32-2. SPECIFICATIONS.

a. The AN/FRC-( ) receiver, operating at an RSL corresponding to a BER of $1x10^{-7}$ bits, shall provide carrier and clock recovery within 1.0 msec. Once carrier recovery and bit synchronization have been achieved, BCI due to loss of bit synchronization shall be maintained for not less than 1 minute when the input RSL is reduced by 15 dB below the RSL specified for a BER of $5x10^{-9}$. See table 10-2 for typical RSL performance. (CCC-77049)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

32-3. TEST EQUIPMENT REQUIRED.

a. Data test set, MBS.

b. Data test set, SCBS.

c. Oscilloscope.

d. Turnaround mixer.

e. RF variable attenuators.

f. Adapters, connectors, and cables as required.

g. Voltmeter.

32-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 32-1 and allow approximately 30 minutes for warmup and stabilization.

b. Omit the turnaround mixer if the transmitter and receiver are tuned to the same frequency. If the mixer is used, adjust AT-1 for a safe operating level into the mixer.

c. With AT-2, establish an RSL corresponding to a BER of $1x10^{-7}$ and transmit data on MBS and SCBS at the designed data rate of the radio for 15 minutes. At the receive end, observe that the BER meets the $1x10^{-7}$.

d. The output level of the pattern generator to the input of the transmitter should be 1 VPP. Measure and record this level on figure 32-2 (USACC Form 642-R). Also measure and record the MBS and SCBS receiver output levels. These levels should be 1 VPP.

e. Calibrate the oscilloscope according to the manufacturer's instructions to display a 2-msec signal across the entire oscilloscope trace. The 1-msec requirement of the radio should then be displayed on the center vertical line of the graticule.

f. Connect the oscilloscope A input to the clock recovery test point and set the oscilloscope for delayed sweep. Connect the oscilloscope B input to the MBS output and adjust to display a data pattern of one complete transition. A 1010 pattern should be provided for each adjustment if the pattern generator has this capability.

g. With the oscilloscope calibrated for the sweep to begin at the first horizontal line of the graticule, momentarily disable the transmit data stream and clock. Restore the transmit data stream and clock, while at the receive end, measure the time for clock and data recovery. Record this value.

h. Establish an RSL corresponding to a BER of $5x10^{-9}$ by adjusting AT-2 while observing the AGC voltage reading. This voltage can be converted to an RSL by using the receiver quieting curve obtained during DT-224 (fig. 27-4).

i. Reduce the RSL by 15 dB from that established for a BER of $5x10^{-9}$ and, at the receive end, observe that the BCI is maintained for not less than 1 minute after loss of bit synchronization. Record the results.

32-5. DATA RECORDING AND ANALYSIS.

a. Review all test data to ensure that it is complete and accurate. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio set fails to meet specified performance, notify the responsible activity of required corrective actions.

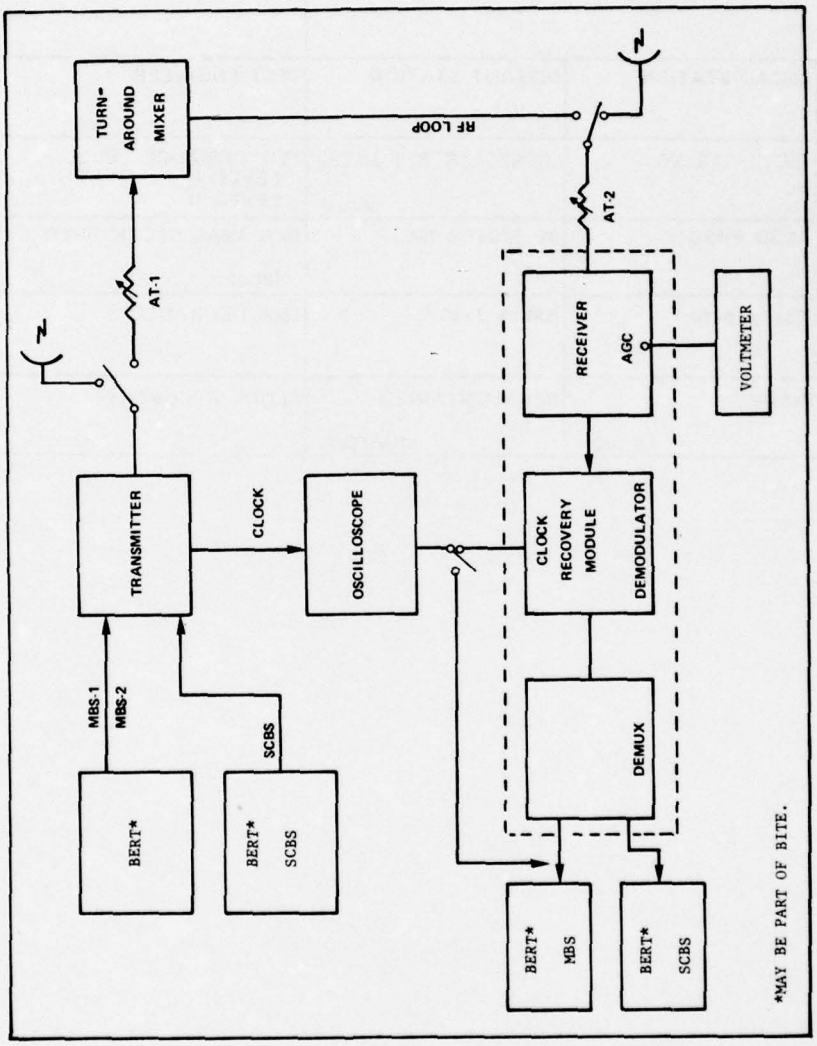


Figure 32-1. Receive carrier and clock recovery test setup.

CARRIER AND CLOCK RECOVERY (CCR 702-1-3)			PAGE OF PAGES
DATA SHEET			DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	AGGREGATE BIT RATE mb/s	PERFORMANCE LEVEL LEVEL I ☐ LEVEL II ☐
LINK ☐ LOOP ☐	ASGD FREQ	BB FILTER BW	INTERNAL CLOCK FREQ (PLL)
LINK RSL (MDN)	RSL = 5×10^{-9}	RSL = 1×10^{-7}	SNR DEGRADED dB
CARRIER RECOVERY msec		BCI MAINTAINED MINUTES	CLOCK RECOVERY msec
COMMENTS			

USACC FORM 642-R
1 MAY 79

Figure 32-2. Carrier and clock recovery data sheet.

CHAPTER 33

TRANSMITTER AND RECEIVER MONITORING AND ALARM FUNCTIONS (DT-230)

33-1. GENERAL.

a. The purpose of this test is to verify the monitor and alarm requirements as well as determine their performance characteristics.

b. This test is not applicable to the three-level, partial-response radio due to differences in requirements.

c. This test may be performed on contractor EF&I systems to ensure that they meet contract specifications or other applicable documents. It may also be performed by installer or quality assurance personnel during onsite test activities as directed.

d. The specifications contained in paragraph 33-2 are applicable with the radio set looped at the RF interface point; however, part of the test may be performed on a link basis when required.

33-2. SPECIFICATIONS.

a. The radio shall include circuitry to monitor critical functions and provide local and remote alarms in the event of degraded performance or failure. Terminals shall be provided for connection of remote alarm signals. A separate remote alarm shall be provided for each function monitored. The functions monitored shall be those necessary to provide adequate assurance of required subsystem performance. The functions monitored shall include the following: (MIL-STD-188-322)

(1) Loss for more than 10 msec of data or timing transitions in the transmit MBS.

(2) Loss for more than 10 msec of data or timing transitions in the receive MBS.

(3) Transmitter frequency drift exceeding 2 percent of the authorized RF transmission bandwidth.

(4) Receiver frequency drift exceeding 2 percent of authorized RF transmission bandwidth.

(5) Loss of power input to the terminal.

(6) Loss of radio receive frame synchronization.

(7) Identification of active transmitter and receiver.

b. The AN/FRC-( ) radio shall, as a minimum, include circuitry to monitor functions and provide an alarm in the event of any failure listed below. The alarm function shall include: (1) 1-ampere contact closures (form C) for remoting to external alarm monitoring circuitry and (2) illumination of a separate visible alarm indicator on the front of the equipment for each failure. The following functions shall be monitored and alarmed. These indicators shall be visible with all panels attached and doors closed when in normal operating configuration. (CCC-74049)

(1) *Data timing input/output.* All inputs and outputs shall be monitored for loss of data or timing (no transitions for 10 msec or more). The alarm for one MBS or timing input/output shall be disabled when only one MBS or timing input/output is being used. The following are the monitored input/output data and timing functions:

(a) Two MBS inputs with associated timing.

(b) Two MBS outputs with associated timing.

(c) One SCBS with associated timing.

(d) Two MBS transmit clock outputs, phase-locked to the radio transmit clock.

(e) One SCBS transmit clock output, phase-locked to the radio transmit clock.

(f) One external clock input at the MBS rate of the radio internal multiplex.

(g) One recovered receive timing output at the MBS rate of the radio internal multiplex.

(2) *Modulator output.* Each transmitter modulator output shall be monitored for loss of data activity (no transitions for 10 msec or more) and power.

(3) *Demodulator output.* Each receiver demodulator output shall be monitored for loss of activity (no transitions for 10 msec or more).

(4) *Radio frame.* Each internal TDM shall be monitored for loss of receive frame synchronization.

(5) *Transmitter frequency drift.* An alarm indication shall be produced by the radio whenever the average transmit frequency deviates more than 2 percent of the authorized bandwidth.

(6) *Power supply.* A visible indicator shall be provided on the front of each power supply to indicate primary DC power has been applied. In the event primary power is lost or the protective device fails, the indicator shall be extinguished.

(7) *Frame error threshold.* An alarm shall be provided which indicates when the error rate of framing bits exceeds $1x10^{-4}$.

(8) *Terminal status.* Visual indicators shall be provided on the front panel which detail the equipment status of each receiver, transmitter, and power supply as well as the diversity status if switching diversity is used. In addition, manual and remote control switches shall be provided with the terminal. The maintenance switch shall enable the operator to place either transmitter or either receiver in an off-line status. Switching shall introduce no loss of BCI. When one of the maintenance switches has been activated, placing the equipment in an off-line status, all corresponding automatic switchovers shall be inhibited and a light shall be activated to indicate off-line conditions.

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

33-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor mount.

c. Pattern generator, MBS rate.

d. Pattern generator, SCBS rate.

e. Oscilloscope.

f. Ohmmeter.

g. Attenuators.

h. Turnaround mixer.

i. Pattern receiver MBS-1.

j. Pattern receiver SCBS.

k. Voltmeter.

33-4. TEST PROCEDURES. The radio will probably contain an alarm monitor subsystem where all visual and audible alarms can be observed from a central point. A block diagram of such a subsystem, which may be incorporated into the AN/FRC-( ), is shown in figure 33-1. This system contains those functions specified in paragraph 33-2b. A typical list of functions that may be monitored in the fully digitized radio and the format in which the functional indication may be provided are listed in table 33-1. These functions and the circuitry shown in figure 33-1, may vary depending on the particular radio to be tested. Therefore, test personnel should consult the technical documentation on the radio set under test. The following procedures will be repeated for all radio systems.

a. Power Supply Indicator.

(1) Connect the radio terminal to the external -48 VDC supply and turn on the equipment power supply.

(2) Observe that the power on lamp lights on the monitor alarm panel for both transmit and receive.

(3) Turn off the external -48 VDC power supply and note that the power on light extinguishes.

(4) Turn on the external -48 VDC power supply and the radio internal power supply and note that the power on lamp lights. Allow approximately 30 minutes for warmup and stabilization. With power applied, measure and record the equipment power supply voltages on figure 33-2 (USACC Form 643-R).

b. Modulator Output.

(1) Connect the radio terminal in an RF loopback as shown in figure 1-8 for a frequency diversity terminal and figure 1-9 for a space diversity terminal. If the transmitters and receivers are tuned to the same frequency, omit the turnaround mixer.

(2) Connect the pattern generator to MBS-1, input 1 of transmitter A. Set the output data rate to correspond to the radio under test and adjust the pattern generator output for a 1-VPP, NRZ data signal.

(3) Disable MBS-2 input to the transmitter by activating the MBS-1/MBS-2 switch on the monitor and alarm control panel.

(4) Connect oscilloscope A to the pattern generator output and adjust the sweep speed of the oscilloscope to display a 10-msec time frame over the entire oscilloscope graticule. This should be accomplished using a 1010 pattern or some other suitable signal from the generator.

(5) After calibrating for a 10-msec time period, connect oscilloscope B to the external relay contacts of the monitor alarm unit data and timing loss beam contacts. If the external contacts are dry, connect a signal or voltage source in series with the oscilloscope input. The measurement may also be made by connecting the oscilloscope external trigger input to the external relay contacts.

(6) Once the oscilloscope has been calibrated for a 10-msec sweep, set the pattern generator to a continuous 1 or 0 input to the transmitter internal multiplex input. Transmit the 1 or 0 and observe that an alarm light activates the oscilloscope B channel or trigger. Record the time for alarm activation and relay closure.

(7) Disable MBS-1 and transmit data on MBS-2 as described above. Record the results.

c. Transmit Timing Loss.

(1) With the oscilloscope and equipment connected as described in paragraph 33-4b, temporarily disable the MBS-1 transmit timing and note that an alarm light activates and that relay contact closure occurs within 10 msec. Record the results.

(2) Restore the MBS-1 timing and temporarily disable the MBS-2 timing. Observe that a transmit timing alarm occurs within 10 msec. Also note that the receive timing alarm external contacts activate.

d. Service Channel Bit Stream.

(1) Connect the oscilloscope as described in paragraph 33-4b and place the SCBS at a rate of 192 kb/s.

(2) Transmit a continuous 1 or 0 from the pattern generator at a rate of 192 kb/s.

(3) Observe that a data/timing alarm light activates and the external relay contacts close after 10 msec of no-data transitions.

(4) Restore the system to normal and transmit a 1010 pattern at a 192-kb/s rate. Temporarily interrupt the SCBS transmit timing and observe that an alarm light activates and an external relay contact closure occurs within 10 msec. Record the results.

(5) Turn the transmitter internal/external clock switch to external.

(6) Connect the equipment and calibrate the oscilloscope as described in paragraph 33-4b.

(7) Momentarily disable the external clock input and observe that an alarm light activates and that relay closure occurs. Record the results.

e. Demodulator Output.

(1) Connect the radio in a back-to-back configuration and connect the pattern generator to MBS-1 of the transmitter input.

(2) Set the pattern generator to the mb/s rate of the radio under test at an output level of 1 VPP.

(3) Turn the MBS-1/MBS-2 switch on the monitor alarm panel to MBS-1.

(4) Connect the oscilloscope to the demodulator loss external relay contacts and calibrate the oscilloscope as described in paragraph 33-4b.

(5) Momentarily cause a loss of data transmission at the demodulator/descrambler by placing a ground or a voltage on a logic terminal. (If a test point is available in the demodulator that can be safely used, insert the ground or voltage.)

NOTE: Consult the equipment technical manual to preclude equipment damage.

(6) Observe and record that a demodulator loss alarm activates and the external relay contacts close within 10 msec.

f. Radio Frame Synchronization.

(1) On the radio internal TDM, inhibit the synchronous search or remove the frame synchronous module.

(2) Observe that a frame synchronous alarm on the monitor alarm panel activates. Also note that the external alarm contacts activate.

(3) Record the results.

g. Transmitter Frequency Drift.

(1) Connect the radio transmitter and receiver in a back-to-back configuration. This procedure may also be used for over-the-link testing when required.

(2) If the transmitter is equipped with AFC, turn it off or disable it.

(3) Connect an ohmmeter to the external alarm contacts representing transmitter frequency drift.

(4) Adjust the local oscillator frequency of the transmitter until the transmitter is off the assigned frequency by 2 percent of the authorized bandwidth. Note that the transmit frequency alarm lights and the external relay contacts activate. Record the results.

h. Transmit Power Loss. If the initial power output has not been previously established, it should be measured and recorded before proceeding with this test.

(1) Turn off the transmitter beam current and observe that the loss of transmit power light activates. Also note and record that the external relay contacts representing a transmit loss of power activate.

(2) Reduce the transmit output power with the variable attenuator shown in figure 33-3 if this test is being performed in an RF loop. If performed over-the-link, adjust the transmit power level set control until the output power has been reduced by 3 dB. Note that the transmit power loss light activates and the external relay contacts at the monitor alarm unit close.

(3) Measure the power level at which the alarm activates and enter this data on the data sheet.

i. BER Alarm (Frame Error).

(1) Connect the radio in a back-to-back loop as shown in figure 33-3.

(2) Transmit data at the applicable bit rate of the radio under test and, with AT-2, adjust the RSL to correspond to a BER of $5x10^{-9}$. Transmit data for approximately 15 minutes and observe that the received BER is within the $5x10^{-9}$ requirement.

(3) Adjust AT-2 to correspond to a BER of $1x10^{-4}$. Note that an alarm light activates. Record the results as well as the RSL at which the alarm activates.

j. Terminal Status. Perform the steps on the data sheet and record the results along with any pertinent comments.

33-5. DATA RECORDING AND ANALYSIS.

a. Review all test data to ensure that it is complete and accurate. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the systems to their normal configuration.

c. If a unit fails to meet specified performance, notify the responsible activity of required corrective actions.

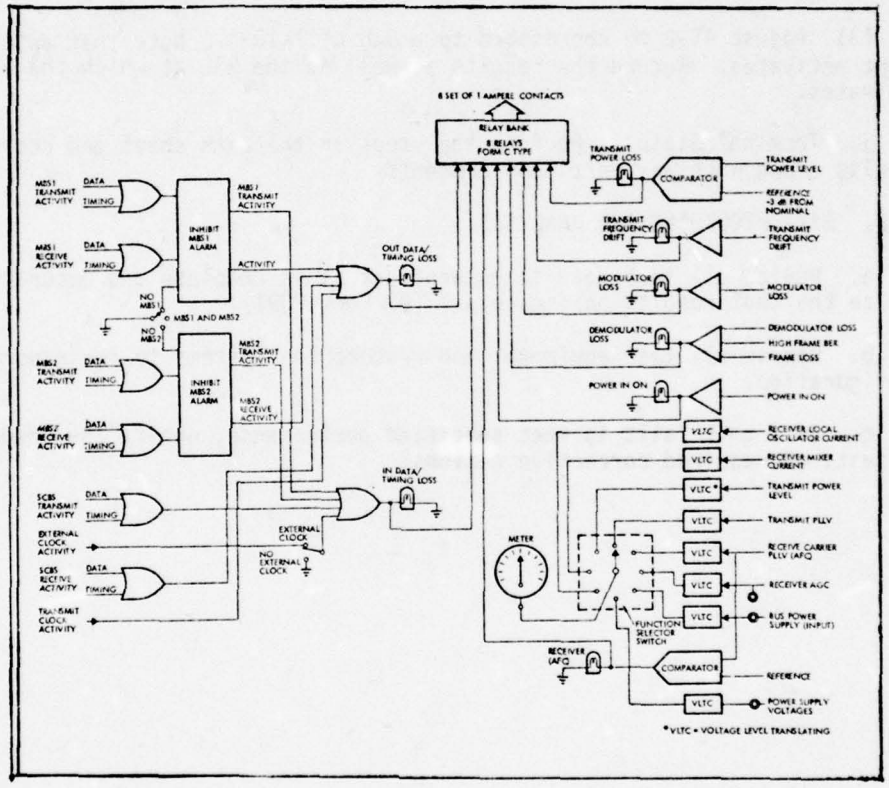


Figure 33-1. Block diagram of monitor and alarm unit, half terminal.

Table 33-1. Example of Monitored Functions

FUNCTION MONITORED	INPUT	OUTPUT	FORMAT		
			TEST POINT	METER	LIGHT
RF PANEL					
RF OUTPUT 1		X	X		
RF OUTPUT 2		X	X		
RX TEST INPUT 1	X		X		
RX TEST INPUT 2	X		X		
DATA INTERFACE					
NO PCN IN	X				X
NO PCN OUT		X			X
TEST MODE					X
CHANNEL A NRZ INPUT	X		X		
CHANNEL B NRZ INPUT	X		X		
SYM CLOCK INPUT	X		X		
CHANNEL A NRZ OUTPUT		X	X		
CHANNEL B NRZ OUTPUT		X	X		
SYM CLOCK OUTPUT		X	X		
MODULATOR					
NO DATA		X			X
LOOP-BACK MODE					X
CHANNEL A NRZ	X		X		
CHANNEL B NRZ	X		X		
IF TEST OUT		X	X		
CRYSTAL OSCILLATOR MON.		X	X		
RB MONITOR		X	X		
DEMODULATOR					
PPL ERROR		X			X
LOW SIGNAL	X				X
A PHASE DETECTOR		X	X		
B PHASE DETECTOR		X	X		
TEST IF IN	X		X		
70 MHZ MONITOR		X	X		
DATA RECOVERY					
A NO NRZ		X			X
B NO NRZ		X			X
QPR MODE					X
QPSK MODE					X
CHANNEL A NRZ		X	X		
CHANNEL B NRZ		X	X		
SYM CLOCK		X	X		
CLOCK MONITOR		X	X		
SIGNAL QUALITY					
PR ERROR		X			X
MP ERROR		X			X
SNR		X	X		
RSL		X	X		
NOISE MONITOR		X	X		
DEMULTIPLEXER CONTROL AND ALARM LOGIC					
MBS 1 DATA		X			X
MBS 2 DATA		X			X
MBS 1 CLOCK		X			X
MBS 2 CLOCK		X			X
SCBS DATA		X			X
SCBS CLOCK		X			X
CONTROL PANEL					
SYNCH ALARM		X			X
SYNCH		X			X
FRAME T.P.		X	X		
MULTIPLEXER T.P.		X	X		
DEMULTIPLEXER T.P.		X	X		
MULTIPLEXER CONTROL AND ALARM LOGIC					
MBS 1 DATA	X				X
MBS 2 DATA	X				X
MBS 1 CLOCK	X				X
MBS 2 CLOCK	X				X
SCBS DATA	X				X
SCBS CLOCK	X				X
MONITOR AND ALARM SUBSYSTEM					
IN DATA TIMING LOSS	X				X
OUT DATA TIMING LOSS	X				X
TRANSMITTER POWER LOSS	X				X
TRANSMITTER FREQ. DRIFT	X				X
MODULATOR LOSS	X				X

FUNCTION MONITORED	INPUT	OUTPUT	FORMAT		
			TEST POINT	METER	LIGHT
DEMODULATOR FRAME LOSS		X			X
RX PLL VOLTAGE		X			X
POWER ON		X			X
RSL OUTPUT		X	X		
NO EXT CLOCK		X			X
NO MBS 1		X			X
NO MBS 2		X			X
RX PLL VOLTAGE		X		X	
RCVR AGC		X		X	
BUSS SUPPLY VOLTAGE		X		X	
TX OUTPUT POWER		X		X	
TX PLL VOLTAGE		X		X	
RX MIXER CURRENT		X		X	
RX LO CURRENT		X		X	
DIVERSITY PROTECTION CONTROL PANEL					
RX 1 OFF LINE		X			X
RX 1 ON LINE		X			X
RX 2 OFF LINE		X			X
RX 2 ON LINE		X			X
AUTO ON LINE		X			X
TX 1 OFF LINE		X			X
TX 1 ON LINE		X			X
TX 2 OFF LINE		X			X
TX 2 ON LINE		X			X
AUTO ON LINE		X			X
RX 1		X			X
RX 2		X			X
TX 1		X			X
TX 2		X			X
BUILT IN TEST EQUIPMENT					
BITE TRANSMITTER CLOCK		X	X		
BITE TRANSMITTER CLOCK LOST		X			X
TRANSMITTER TIMING		X	X		
TRANSMITTER TIMING LOST		X			X
TRANSMITTER DATA		X	X		
TRANSMITTER DATA LOST		X			X
RADIO TRANSMITTER CLOCK	X		X		
RADIO TRANSMITTER CLOCK LOST		X			X
RX TIMING	X		X		
RX TIMING LOST		X			X
RX DATA	X		X		
RX DATA LOST		X			X
TRANSMITTER ERROR INJECTION	X		X		
ERROR		X			X
ERROR 10^{-4}		X			X
ERROR COUNT		X	X		
TRANSMITTER SYNC		X	X		
TRANSMITTER DATA		X	X		
RX DATA	X		X		
POWER SUPPLY					
ON		X			X
-48 VOLTS		X	X		
-15 VOLTS		X	X		
+15 VOLTS		X	X		
-12 VOLTS		X	X		
+5 VOLTS		X	X		
-6 VOLTS		X	X		
TRANSMIT POWER SUPPLY					
OFF/ON		X		X	
BEAM CURRENT		X		X	
HELIX CURRENT		X		X	
BEAM CURRENT ALARM		X			X
HELIX CURRENT ALARM		X			X
JACK PANEL					
EXT CLOCK	X		X		
MBS TRANSMITTER CLOCK	X		X		
MBS TRANSMITTER TIMING 1	X	X	X		
MBS TRANSMITTER TIMING 2	X		X		
MBS TRANSMITTER DATA 1	X		X		
MBS TRANSMITTER DATA 2	X		X		
MBS RECEIVER CLOCK		X	X		
MBS RECEIVER DATA 1		X	X		
MBS RECEIVER DATA 2		X	X		
SCBS TRANSMITTER TIMING	X		X		
SCBS TRANSMITTER DATA	X		X		
SCBS RECEIVER TIMING		X	X		
SCBS RECEIVER DATA		X	X		

INTENTIONALLY LEFT BLANK

DIGITAL RADIO MONITOR AND ALARMS (CCR 702-1-3)

DATA SHEET

PAGE OF PAGES

DATE (DAY, MO, YEAR)

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

XMTR SER NO.	RCVR SER NO.	AGGREGATE BIT RATE mb/s	PERFORMANCE LEVEL I ☐ II ☐

LINK ☐ LOOP ☐	ASGD FREQ MHz	RSL = 6×10^{-9} dBm	ASGD BANDWIDTH MHz

XMT POWER dBm	SCBS LEVEL VPP	MBS-1 _____ VPP MBS-2 _____ VPP

POWER SUPPLY

REQUIREMENT	MEASURED	RESULTS
DC POWER ON		LIGHT ON ☐
DC POWER OFF		LIGHT OFF ☐
DC POWER ON		RELAY ACTIVATES ☐
-48 VDC - -12 VDC	-48 VDC -12 VDC	ADJ RQR
-15 VDC - +15 VDC	-15 VDC +15 VDC	
+ 5 VDC - -6 VDC	+5 VDC -6 VDC	

ALARM CONDITIONS

CONDITION	SWITCH TIME (msec)	ALARM IND		EXT RELAY CONTACTS	
		OFF	ON	OPEN	CLOSED
XMT NO TRANSITIONS MBS-1					
XMT NO TRANSITIONS MBS-2					
RCV NO TRANSITIONS MBS-1					
RCV NO TRANSITIONS MBS-2					
NO TRANSITIONS SCBS					
MBS-1 XMT TIMING					
MBS-2 XMT TIMING					
SCBS TIMING					
EXTERNAL CLOCK DISABLE					
TDM FRAME SYNC LOSS					

COMMENTS

USACC FORM 643-R
1 MAY 79

Figure 33-2. Digital radio monitor and alarm data sheet.

ALARM CONDITIONS

CONDITION	SWITCH TIME (msec)	ALARM IND EXT RELAY CONTACTS			
		OFF	ON	OPEN	CLOSED
RSL - BER 1×10^{-4}					
XMT POWER 3 dB DOWN					
XMT FREQ DRIFT 2% OF ASGD BW					

TERMINAL STATUS

CONDITION	INDICATOR ACTIVATED	
	YES	NO
RCVR 1 ON-LINE, RCVR 2 OFF-LINE		
RCVR 2 ON-LINE, RCVR 1 OFF-LINE		
XMTR 1 ON-LINE, XMTR 2 OFF-LINE		
XMTR 2 ON-LINE, XMTR 1 OFF-LINE		
POWER SUPPLY 1 FAILURE		
POWER SUPPLY 2 FAILURE		
DIVERSITY SWITCHING		

MAINTENANCE SWITCH

CONDITION	MANUAL IND		LOSS OF BCI		REMOTE IND		LOSS OF BCI	
XMTR 1 - RCVR 1	YES	NO	YES	NO	YES	NO	YES	NO
XMTR 2 - RCVR 1								
XMTR 1 - RCVR 2								
RCVR 2 - RCVR 2								

ON-LINE/OFF-LINE INDICATORS ☐ YES ☐ NO

COMMENTS

USACC FORM 643-R
1 MAY 79

Figure 33-2. Digital radio monitor and alarm data sheet. (continued)

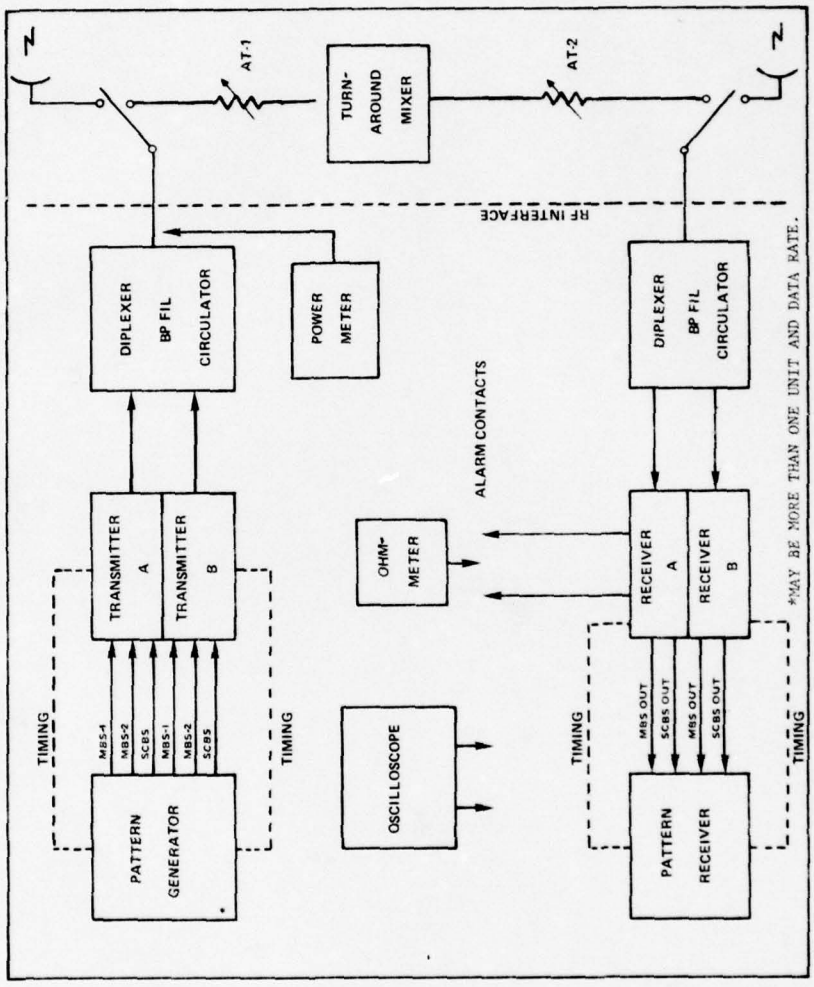


Figure 33-3. Monitor and alarm (transmit power) test setup.

CHAPTER 34

MONITOR AND ALARMS, AN/FRC-162 RADIO (DT-231)

34-1. GENERAL.

a. The purpose of this test is to measure and determine the alarm characteristics of the AN/FRC-162.

b. Many radios incorporate a visual and audible alarm system for status alerting. These alarms may be divided into major and minor categories for alerting operating personnel of equipment failure or system degradation. These alarms may also be remoted through external relay contacts to a central location within a TCF or a centralized maintenance activity.

c. This test may be performed in an over-the-link or RF loop configuration. The specifications contained in paragraph 34-2 are primarily applicable to an RF loop configuration, but also may apply to link testing.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be performed by installer and quality assurance personnel during onsite test activities as directed.

34-2. SPECIFICATIONS.

a. The radio shall be provided with circuitry to monitor the following functions and provide an alarm in the event of any failure. The alarm function provided shall include the illumination of visible alarm indicator lamps on the front of the equipment and the operation of normally open dry relay contacts for connection to external alarm monitoring circuitry. (MIL-STD-188-313)

(1) *Transmitter pilot.* The pilot tone shall be monitored for continuity at the FM transmitter output. In systems employing direct modulation of reflex klystrons, they shall be monitored at the RF transmitter output.

(2) *Transmitter output power.* The transmitter output power level shall be monitored to detect any decrease below a preset, adjustable level.

(3) *Receiver pilot.* The pilot tone shall be monitored for continuity at the receiver.

(4) *Receiver noise.* The receiver noise level shall be monitored to detect any increase above a preset, adjustable level.

(5) *Combiner action.* Diversity combiner action shall be monitored to detect the muting of either receiver.

(6) *Received RF signal level.* The received RSL shall be monitored to detect any decrease below a preset, adjustable level.

(7) *IF carrier resupply.* The IF carrier resupply shall be monitored to detect failure of the 70-MHz input carrier to the radio transmitter.

b. The AN/FRC-162 radio set shall include, as a minimum, circuitry to monitor functions and provide an alarm in the event of any failure listed below. The alarm function shall include an audible alarm, the illumination of a separate visible alarm indicator lamp on the front of the equipment, and activation of separate form C dry relay contacts or equivalent for each alarm function for connection to external alarm monitoring circuitry. The following functions shall be monitored and alarmed: (SCCC-73017)

(1) Transmitter radio pilot continuity of each transmitter.

(2) Transmit output power reduction below a preset, adjustable threshold.

(3) Receiver radio pilot level decrease below a preset, adjustable threshold.

(4) Receiver noise increase above a preset, adjustable threshold.

(5) Combiner performance failure.

(6) Squelching of any receiver.

(7) Loss of transmitter or receiver AFC or phase-lock loop.

(8) Failure of any power supply.

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

34-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. Voltohmmeter.

c. Directional couplers.

d. RF variable attenuators.

e. Frequency selective voltmeter.

f. Adapter and connectors, as required.

34-4. TEST PROCEDURES.

a. General.

(1) Connect the radio set as shown in figure 34-1 and allow approximately 30 minutes for warmup and stabilization. If the test is to be performed in an

RF loop configuration and the transmitter and receiver are tuned to the same frequency, omit the turnaround mixer.

(2) With the radio set in a back-to-back configuration, adjust the waveguide attenuator to provide an RSL of -30 dBm into each receiver. If performed on a link basis, use the nominal RSL. If the test is being performed on a system that has already been installed with the external alarms extended, as a failure is simulated, either measure the external contact closure or observe the external alarms. As each alarm is activated, a visible alarm, an audible alarm, and a change of state of the relay contacts should occur. The audible alarm will be disabled upon correction of the alarm and upon placing the alarm switch to normal. Record all test results on figure 34-2 (USACC Form 644-R).

(3) Repeat the procedures for transmitter B and receiver B.

(4) Refer to tables 34-1 and 34-2 for external alarm conditions.

b. Transmitter Pilot.

(1) Connect the frequency selective voltmeter to test point J1-A and measure the pilot level. The level should be -70 dBm. If this level is incorrect, adjust the pilot oscillator level for -70 dBm as read at test point J1-A. Note and record the level on the data sheet.

(2) Reduce the pilot level by adjusting the pilot oscillator level control until a transmit pilot alarm activates. This should be 3 dB; however, it will depend on the adjustment of the alarm level circuitry. If the 3-dB requirement is not met, adjust the alarm level control until the alarm activates when the pilot level is reduced 3 dB from the nominal -70 dBm level.

(3) Note and record that a transmit pilot alarm was received at the receiver alarm control unit.

(4) Adjust resistor R36 in the alarm control unit and verify that the alarm can be turned off and on.

(5) Connect an ohmmeter between pins D and E of J103 in the control unit and verify that the contacts close when an alarm is received.

c. Transmitter Output Power.

(1) Verify that the transmitter output power is within specifications by performing the output power test. Record the output power on the data sheet.

(2) Remove the RF power detector at the waveguide filter assembly and insert a 3-dB attenuator between the coupler and detector as shown in figure 34-3. THe visual and audible alarms should activate. Remove the 3-dB attenuator and insert a 6-dB attenuator. Adjust R6 in the control unit to verify that the alarm can be adjusted.

(3) Measure between terminals A and B of J103 to verify that the external relay contacts are closed.

(4) Remove the attenuators and restore R6 to activate a power alarm when the transmit power is reduced by 3 dB.

d. Receive Radio Pilot.

(1) Connect the frequency selective voltmeter to J58-A and measure the pilot level. The level should be -41 dBm.

(2) At the transmitter, attenuate the pilot oscillator by 3 dB, and at the receiver, note that a receive pilot alarm is received. Restore the transmit level.

(3) Remove the looping plug between J5 and J30 and note that a pilot alarm activates.

(4) Connect a 3-dB attenuator between J5 and J30. The receive pilot alarm should activate unless it was set for some other level. If it does not activate with 3 dB of attenuation, insert additional attenuation until an alarm occurs.

(5) Measure between terminals X and Y of J103 to determine if the external contacts have activated.

(6) Restore all levels and alarms to their normal condition.

e. Receiver Noise Increase Above a Preset, Adjustable Level.

(1) On the receiver IF module, turn the receiver squelch adjustment fully counterclockwise.

(2) With the variable attenuator, reduce the RSL until a receiver squelch alarm occurs.

(3) Increase the RSL by 10 dB and adjust the squelch control until receiver squelch reoccurs.

(4) At J103, measure between terminals K and L to verify that the external alarms function. Record the results on the data sheet.

NOTE: Some receivers may be equipped with noise alarm indicators and, if so, when the RSL is reduced to a preset level with the squelch control set to receiver threshold, a noise alarm should be activated. The external contacts for this may appear on terminals N and P of J103.

f. Receiver Phase-Lock Alarm.

(1) Connect the oscilloscope to phase-lock terminal 4 on the receiver local oscillator.

(2) Slowly adjust the power oscillator tuning screw until a phase-lock alarm occurs. Note on the oscilloscope that phase-lock is not lost.

(3) Verify that visual and audible alarms were received.

(4) With the voltohmmeter, measure for continuity between terminals V and 12 of J103.

(5) Record the results on the data sheet and restore the power oscillator to the correct frequency.

g. Transmitter AFC or Phase-Lock Loop.

(1) Disconnect the power to the transmit oscillator and turn the transmit AFC on. The transmit AFC visual and audible alarms should activate.

(2) Measure between terminals D and E of J103 for continuity.

(3) Reconnect the power cable. The alarm should function intermittently until the AFC unit stabilizes.

h. Receiver Switching.

(1) Place receiver A on-line and turn the switching unit to normal.

(2) Reduce the receiver A RSL until a receive switch alarm occurs.

(3) Observe that the receiver A switch alarm (visual and audible) activates. Verify that this receiver cannot be switched on-line.

(4) Measure for continuity between terminals X and Y of J103.

i. Power Alarms.

(1) Remove fuse A1 (transmit and receive) from the primary power supply.

(2) Observe that visual and audible alarms activate. Most of the A alarms should activate. Restore the fuse.

(3) Measure for continuity between terminals G and H of J103.

(4) Remove fuse A2 (auxiliary) from the fuse panel. The auxiliary A supply alarm should activate. Measure for continuity between terminals K and M of J103.

(5) Disconnect the drive to the traveling wave tube. A traveling wave tube power alarm should activate. Measure for continuity between terminals A and B of J103.

(6) Remove fuse A3 (traveling wave tube) from the fuse panel. A traveling wave tube power supply alarm should occur at J103.

(7) Turn off the transceiver A DC power circuit breaker on the power control panel. Observe that the primary power alarm activates. Measure for continuity between terminals P and Q of J103.

j. Fuse Alarm. In any fuse position, insert a blown fuse. The fuse alarm indicator should light and an audible alarm should occur.

34-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review all test results to verify compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Restore the system to normal operation.

c. If the radio set fails to meet specifications, notify the responsible activity of required corrective actions.

Table 34-1. External Relay Contacts, AN/FRC-162 Radio

RADIO A J103 TML	RELAY CONTACT	FUNCTION	RADIO B J104 TML
A B C	No Armature No connection	Transmit power	A B C
D E F	No Armature No connection	Transmit AFC	D E F
G H J	No Armature No connection	Transmit pilot	G H J
K L M	No Armature No connection	Receive squelch	K L M
N P R	--	--	N P R
S T U	--	--	S T U
V W J	No Armature No connection	Receive phase-lock	V W J
X Y Z	No Armature No connection	Receive switch	X Y Z
A B C	No Armature No connection	TWT power out	A B C
D E F	No Armature No connection	TWT power supply	D E F
G H S	No Armature No connection	Xmt/rcv power supply	G H S
K M N	No Armature No connection	Aux power supply	K M N
P Q R	No Armature No connection	Primary power supply	P Q R

Table 34-2. Remote Control Functions

CONNECTOR	TML	RELAY CONTACT	FUNCTION
J105	A	No	Service channel
	B	Armature	Receive signaling
	C	No connection	--
	E	--	Service channel xmt signaling
	F	--	Channel A switchover
	G	--	Channel B switchover
J111	A	A	Indicator
	B	A	Indicator
	C	A	AGC
	D	A	Remote drive
	E	Ground	--
	F	Ground	--
	G	B	Remote drive
	H	B	AGC
	J	B	Indicator
	K	B	Indicator

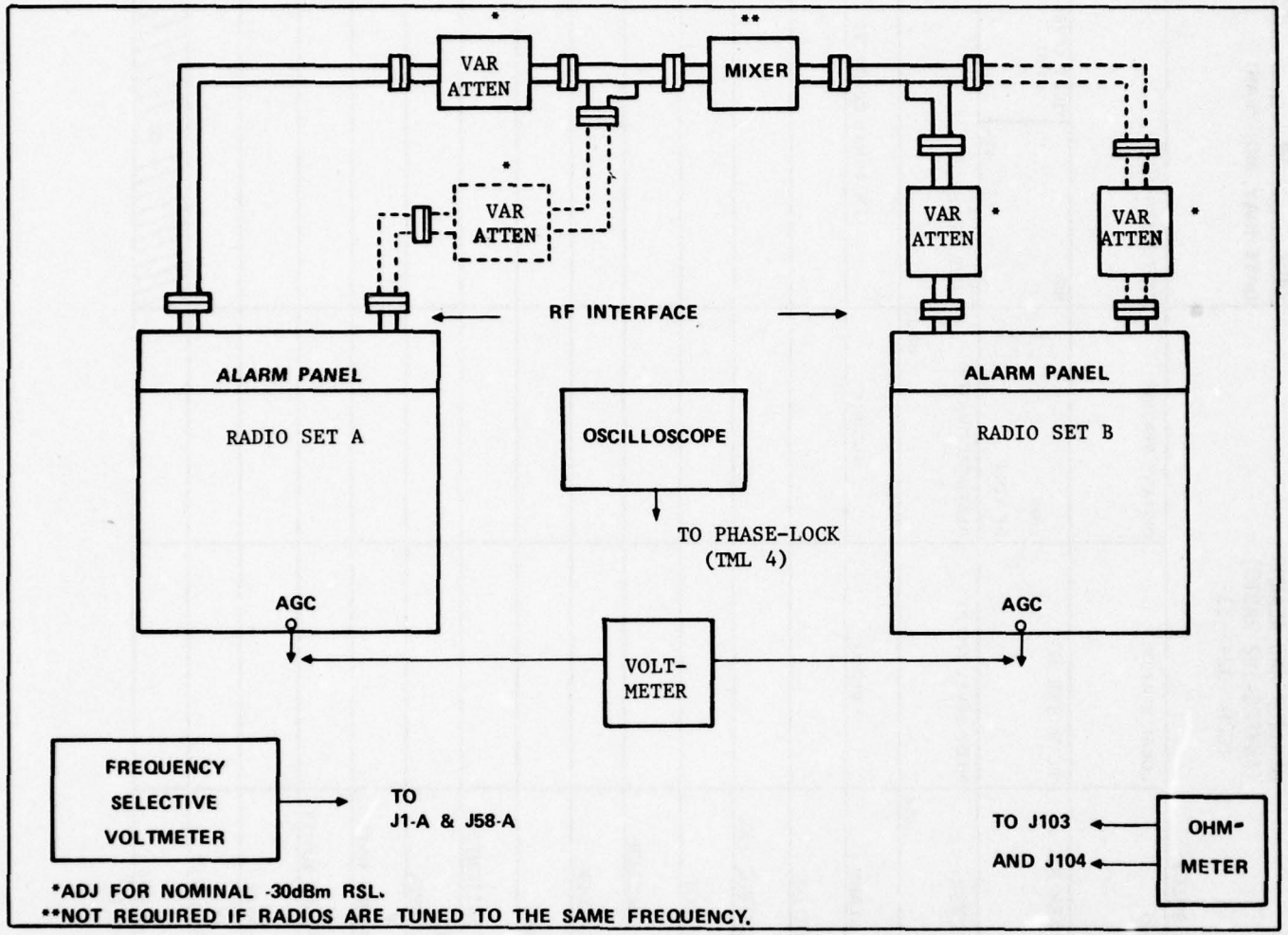


Figure 34-1. Monitor and alarm (AN/FRC-162) test setup.

MONITOR AND ALARMS (AN/FRC-162 RADIO) (CCR 702-1-3) DATA SHEET			PAGE ___ OF ___ PAGES DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	LINK ☐ RF LOOP ☐	RSL dBm / PILOT LEVEL (J1-A) dBm
XMT POWER dBm	PILOT LEVEL (J58-A)	ALARM ACTIVATES dBm	RCVR SQUELCH dBm
ALARM	VISUAL	AUDIBLE	EXTERNAL CONTACTS
XMT PILOT			
XMT OUTPUT PWR			
RCV PILOT			
RCVR SQUELCH			
RCVR PHASE-LOCK			
XMT AFC			
RCVR SWITCHING			
XMT/RCV PWR SUPPLY			
AUX POWER SUPPLY			
TWT POWER SUPPLY			
TWT POWER			
PRIMARY POWER SUPPLY			
FUSE ALARM			NC
COMMENTS			

USACC FORM 644-R
1 MAY 79 Figure 34-2. Monitor and alarms (AN/FRC-162 radio) data sheet.

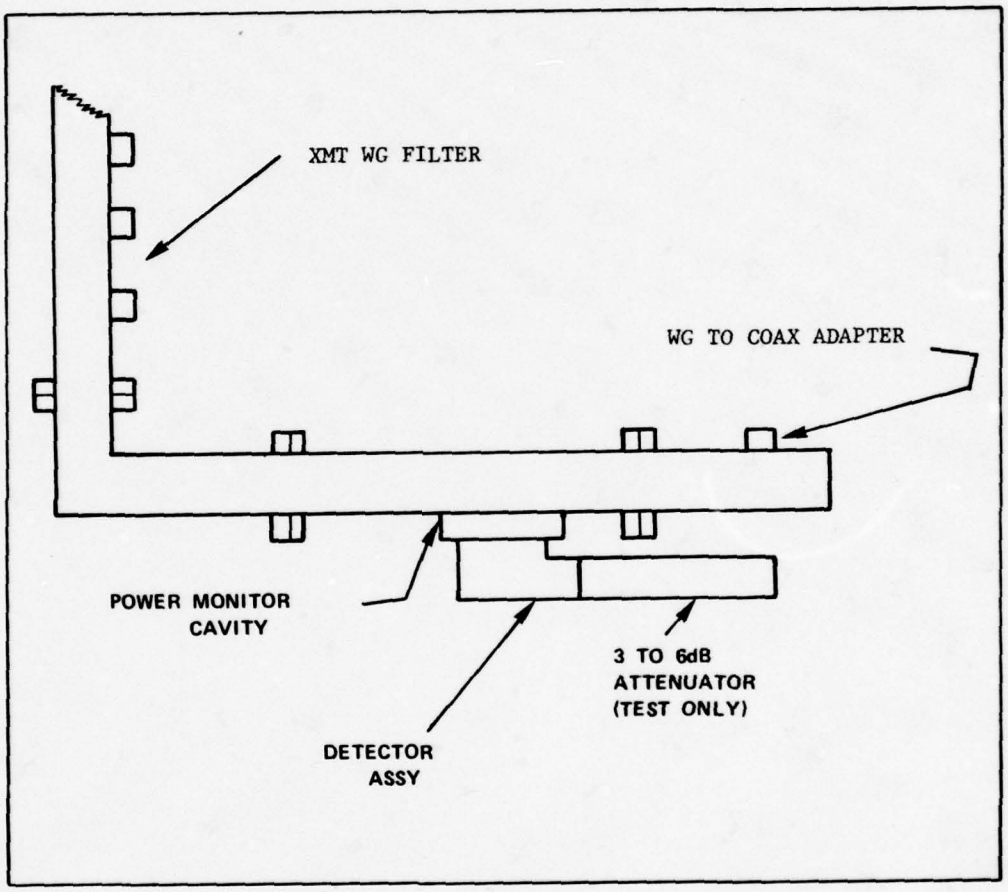


Figure 34-3. Transmit power monitor assembly (AN/FRC-162) test setup.

CHAPTER 35

TRANSMITTER-RECEIVER ISOLATION (DT-232)

35-1. GENERAL.

a. The purpose of this test is to measure and determine the RF isolation between transmitters and receivers by measuring the spurious signals introduced by the transmitter into the receiver.

b. The spurious signals that may result from poor isolation between the transmitter-receiver can introduce distortion and interference into the receive RF and baseband spectrum. This unwanted distortion and interference may affect the quality of communications if of sufficient magnitude and phase relationships.

c. In performing this test, all test leads should be kept as short as possible, all test equipment should be properly grounded, and proper safety precautions should be observed.

d. This test is not directly applicable to the fully digitized radio; however, it may be performed in conjunction with DT-228.

e. This test may be performed on contractor EF&I systems to ensure that they meet contract specifications. It may also be performed by installer or quality assurance personnel during onsite test activities or as a diagnostic aid in isolating a feedover problem as directed. However, this should not be considered a routine field test unless other test sequences indicate a problem with transmitter-receiver isolation.

35-2. SPECIFICATIONS.

a. The isolation between ports of the waveguide switch shall be at least 70 dB. (MIL-STD-188-313)

b. When transmitters and receivers (AN/FRC-162) operate into the same waveguide run, each receiver shall provide specified performance when its frequency is separated from the nearest transmit frequency by as little as 100 MHz. The waveguide switch shall have 70 dB of isolation. (SCCC-73017)

c. A similar requirement is described in paragraph 31-2b of DT-228 for the AN/FRC-( ).

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

35-3. TEST EQUIPMENT REQUIRED.

a. Spectrum analyzer.

b. Variable attenuators.

c. Voltmeter.

d. BER test set.

e. Directional coupler.

f. RF sweep generator.

g. Microwave amplifier.

35-4. TEST PROCEDURES. This test may be performed on a link basis; however, the specifications contained in paragraph 35-2 are primarily applicable to RF loop testing. Repeat the procedures for other transmitter-receiver combinations to be tested.

a. Absolute Power.

(1) Connect the test equipment as shown in figure 35-1 (calibration) and allow approximately 30 minutes for warmup and stabilization.

(2) Select an RF attenuator with sufficient power handling capability and a range of attenuation to ensure that the input to the spectrum analyzer does not exceed a safe operating level.

(3) Adjust the analyzer for a convenient display with the internal and external attenuators. The display should closely approximate the output level of the transmitter.

(4) Connect the spectrum analyzer to the transmitter RF test point. Measure and record the absolute power in dBm of the transmitter carrier, taking into consideration the directional coupler loss factor. This loss factor is usually stamped on the coupler. Enter the coupling loss on figure 35-2 (USACC Form 645-R).

NOTE: The transmit baseband of the AN/FRC-162 radio should initially be terminated.

(5) Calculate the translated transmit frequency appearing in the IF by the following formula:

$$F - 70 + T - R \text{ (MHz)}$$

Where:

R = receive frequency
T = transmit frequency
F = translated transmit frequency appearing in the IF

(6) Connect the calibrated spectrum analyzer to the IF output and tune the analyzer to the frequency calculated in paragraph 35-4a(5), above.

(7) Measure the peak power of the transmit signal appearing in the IF and record this value on the data sheet. Subtract this value from the value

recorded in paragraph 35-4a(4) to obtain the transmitter-receiver isolation. Record this value on the data sheet.

(8) If the test is to be performed with modulation applied, connect a BER test set or digital multiplexer to the transmitter baseband input. Adjust the input level for 1 VPP. In the case of the fully digitized radio, disable MBS-2 and apply the data to MBS-1, at the appropriate bit rate for the radio under test.

(9) Measure the IF output as outlined above with and without modulation. In this case the peak spectrum power will be measured.

b. Relative Power.

(1) Connect the calibrated spectrum analyzer to the transmitter RF test point and adjust the attenuator to display the peak of the transmitted spectrum at a convenient graticule. Record this value of attenuation in the initial attenuation column of the data sheet. Record the directional coupler value on the data sheet.

(2) Calculate the translated transmit frequency appearing in the IF as given in paragraph 35-4a(5) and record this information on the data sheet.

(3) Connect the spectrum analyzer to the IF output and tune the analyzer to the calculated transmit translated frequency.

(4) Adjust the IF attenuation to display the transmit signal at the same level as that previously established for the transmit peak output level. Record the attenuation value on the data sheet.

(5) Calculate the isolation using the following formula:

$$I = A - B + C$$

Where:

A = initial attenuation value in dB
B = final attenuation value in dB
C = directional coupler loss in dB

(6) Record the final value of isolation on the data sheet.

c. Back-to-Back RF Loop.

(1) Connect the radio set in a back-to-back RF loop as shown in figure 35-1.

(2) Adjust the variable attenuator to provide an AGC voltage corresponding to -71 dBm. This value should equate to a BER of $1x10^{-7}$. Tune the generator to a frequency of 100 MHz above or below the RF received carrier frequency.

(3) Adjust the microwave amplifier output power to the same level as the normal transmit power. This may be omitted if the transmitter and receiver sharing the same waveguide run have 100-MHz separation.

(4) Transmit data for approximately 15 minutes and observe that the BER is not degraded from the level established in subparagraph (2), above. Record the results on the data sheet.

35-5. DATA RECORDING AND ANALYSIS.

a. Review all data for completeness, accuracy, and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

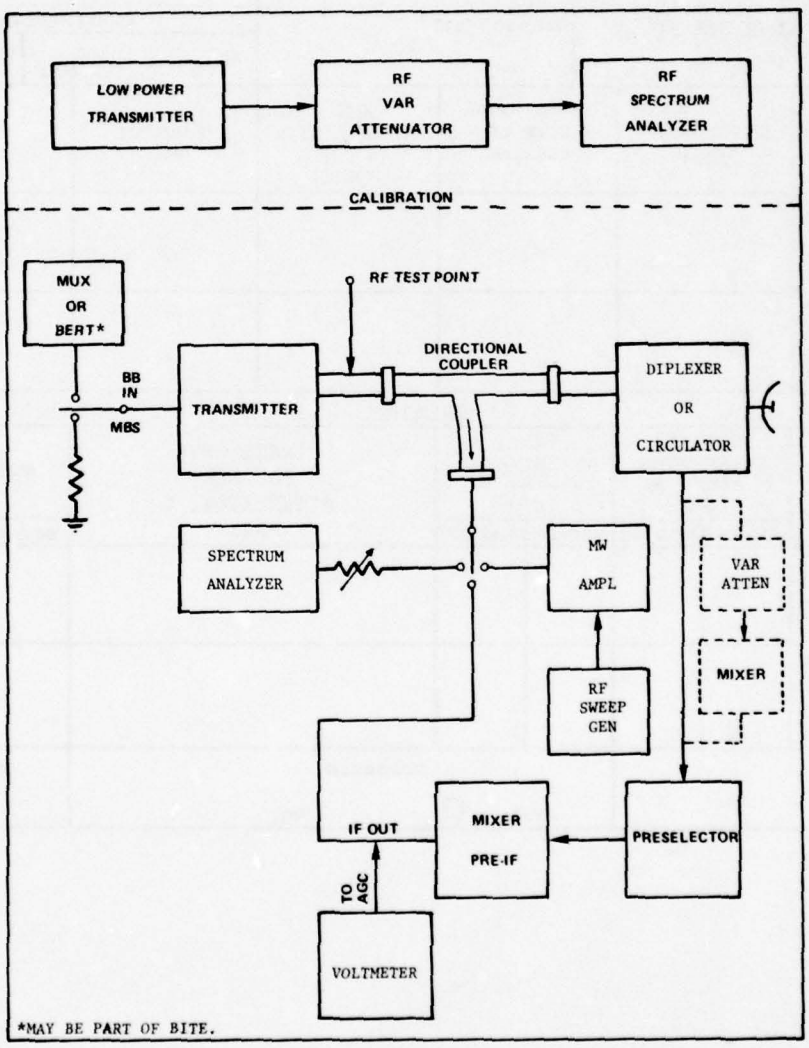


Figure 35-1. Transmitter-receiver isolation test setup.

TRANSMITTER-RECEIVER ISOLATION
(CCR 702-1-3)

PAGE OF PAGES

DATE (DAY, MO, YEAR)

DATA SHEET

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

XMTR SER NO.	RCVR SER NO.	RSL = BER 1×10^{-7}	ASGD FREQUENCY XMT MHz	ASGD FREQUENCY RCV MHz

EQUIPMENT XMTR/RCVR NO.	XMT POWER (dBm)	DIRECTIONAL COUPLER LOSS (dB)	XMT TRANSLATED FREQ (MHz)	IF OUTPUT (dBm)	ISOLATION (dB)
XMTR ☐					
RCVR ☐					
XMTR ☐					
RCVR ☐					

RELATIVE

EQUIPMENT XMTR/RCVR NO.	INITIAL ATTENUATOR VALUE, A (dB)		FINAL ATTENUATOR VALUE, B (dB)		DIRECTIONAL COUPLER ATTENUATOR, C (dB)	ISOLATION (dB)	
	MOD OFF	MOD ON	MOD ON	MOD OFF		MOD ON	MOD OFF
XMTR ☐							
RCVR ☐							
XMTR ☐							
RCVR ☐							

BER 1×10^{-7}	DEGRADED	IF LEVEL
	YES ☐ NO ☐	dBm

COMMENTS

USACC FORM 645-R
1 MAY 79

Figure 35-2. Transmitter-receiver isolation data sheet.

CHAPTER 36

TRANSMITTER OUTPUT POWER AND ANTENNA SYSTEM REFLECTED POWER (DT-233)

36-1. GENERAL.

a. The purpose of this test is to measure the power output (forward power) of the radio transmitter at the RF interface point and the reflected power of the antenna and transmission lines.

b. Measurement of the VSWR and impedance discontinuities of the antenna and transmission lines are contained in preceding chapters; however, the VSWR measurement has also been included in this procedure since the two measurements are directly related. Equipment interface VSWR measurement procedures are contained in DT-207.

c. For the purpose of this test, the term transmitter or power amplifier applies to traveling wave tubes and RF solid state oscillators and output devices.

d. Personnel performing this test should exercise caution to preclude injury from microwave radiations.

e. This test is applicable to the AN/FRC-162 as well as the AN/FRC-( ) that will be added to the inventory in the near future.

f. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

36-2. SPECIFICATIONS.

a. The power output of the radio shall not be less than 0.5 watt nor more than 10 watts as measured at the RF interface point. (MIL-STD-188-322)

b. System parameters shall be as shown in figures 36-1 and 36-2. (MIL-STD-188-313)

c. The transmitter output power (AN/FRC-162) as measured at the RF interface point shall be +27 dBm or more. (SCCC-73017)

d. As a minimum, the AN/FRC-( ) radio shall provide the power outputs specified in table 36-1, measured at the RF interface point. The low level power outputs shall be met with an optional power amplifier. The 3.5-MHz power outputs specified in table 36-1 shall be required only for the band 1 configuration (4.4 to 5.0 GHz). (CCC-74049)

Table 36-1. Power Output

TRANSMITTED BANDWIDTH (MHz)*	LOW LEVEL (+dBm)	HIGH LEVEL (+dBm)
3.5	20	27
7.0	23	30
10.5**	25	32
14.0	26	33
20.0**	26	33

*As shown in table 29-3.
**Applicable to band 2 only (7125 to 8400 MHz).

e. The radio shall operate as specified in the standard engineering plan or contract specifications.

36-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor/bolometer.

c. RF attenuators, as required.

d. Directional couplers, as required.

36-4. TEST PROCEDURES.

a. General.

(1) Connect the test equipment as shown in figure 36-3 and allow approximately 30 minutes for warmup and stabilization.

(2) Calibrate the power meter with a termination impedance equal to the transmitter output impedance (50 ohms). Measure the loss of any connecting cables at the frequency of the transmitter and enter this loss on figure 36-4 (DD Form 2121). Also enter the transmitter serial numbers in the comments section of the form.

NOTE: Before connecting the test equipment as shown in figure 36-3, the high voltage to the power amplifier should be turned off to preclude equipment damage or personnel injury.

(3) Repeat the procedures for other radios and transmission lines to be tested.

b. Transmitter Output Power.

(1) With the dual directional coupler and the power meter connected to the forward power point, record the directional coupler attenuation value on the data sheet. This value is usually recorded on the side of the directional

coupler. Select attenuators A and B so that their power ratings will not be exceeded and they attenuate the incident and reflected power to a level that will not damage the bolometer or power meter.

(2) Record the value of the attenuators on the data sheet.

(3) Set attenuator B, used in the reflected power circuit, at a high enough value to act as a termination.

(4) Apply full modulation to the transmitter input. For the AN/FRC-162, this modulation can be provided from a generator whose frequency is approximately equal to the center frequency of the baseband spectrum or from a multiplexer whose output has been adjusted to +2.2 dBm. Input to the fully digital radio can be supplied by a pattern generator or digital multiplex at the specified bit rate and at a level of approximately 1 VPP.

(5) Record the measured output power as reflected on the power meter.

(6) Calculate the output power from the following formula and enter it on the data sheet.

$$P_f = A + L + C + R - 30, \text{ dBw}$$

$$= \text{antilog}_{10} \frac{(A + L + C + R - 30)}{10}, \text{ watts}$$

Where:

P_f = transmitter output power

A = attenuator value (in dB)
C = directional coupler attenuation (in dB)
R = power meter reading (in dB)
L = power loss of connecting line (in dB)

c. Transmission Line Reflected Power.

(1) The measurement of the reflected power is made concurrently with measurement of the transmitter output power by repeating paragraph 36-4b, except that the measurements apply to the reflected power (P_r) instead of the forward power with the bolometer connected to attenuator B.

(2) Calculate the VSWR using the following formula and enter the results on the data sheet:

$$VSWR = \frac{1 + \sqrt{\frac{P_r}{P_f}}}{1 - \sqrt{\frac{P_r}{P_f}}}$$

Where:

VSWR = voltage standing wave ratio
P_f = forward power (watts)
P_r = reflected power (watts)

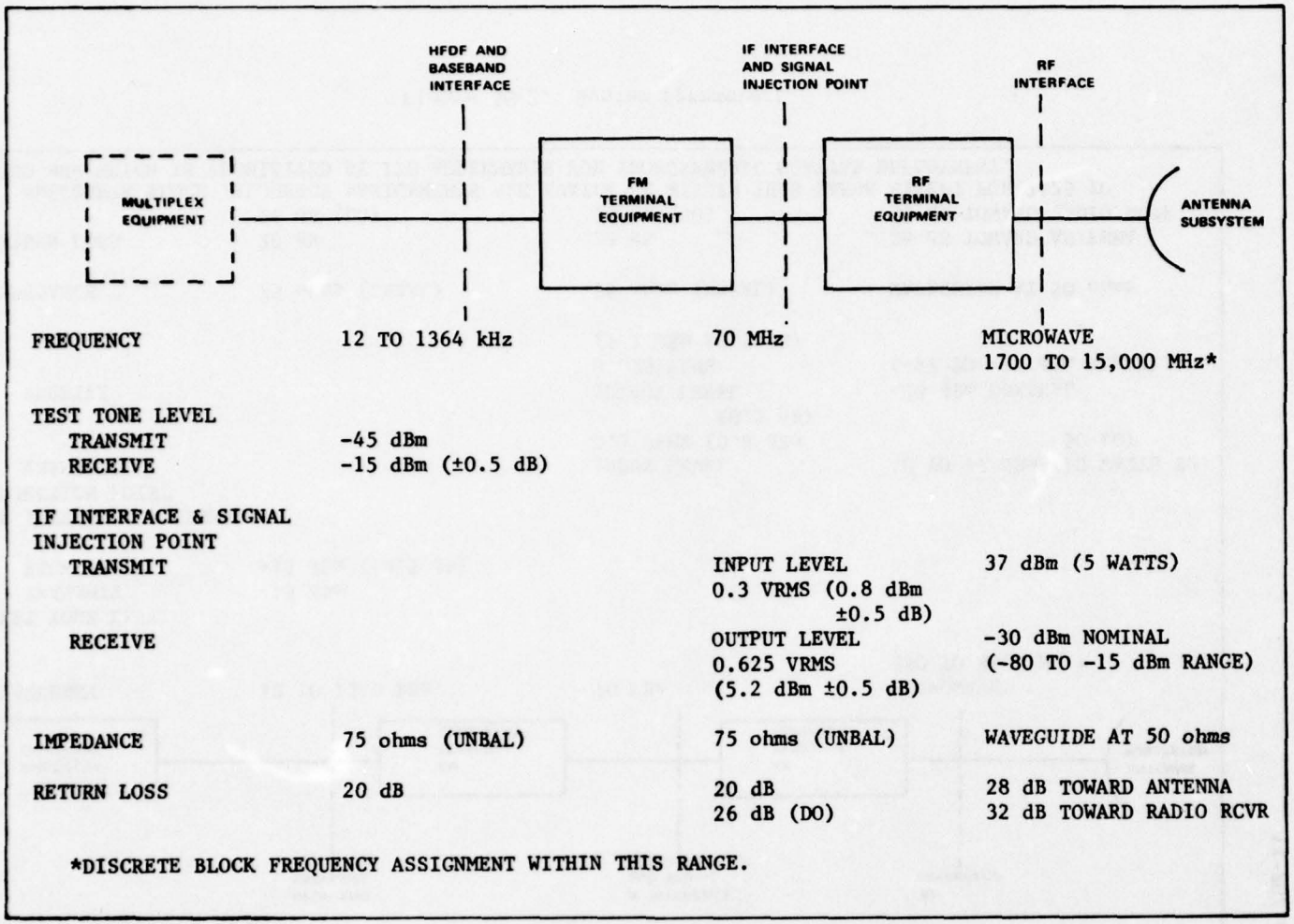
(3) Convert the calculated value(s) of VSWR to return loss, in dB, using table 5-1. Record this value on the data sheet.

36-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for accuracy and compliance with specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

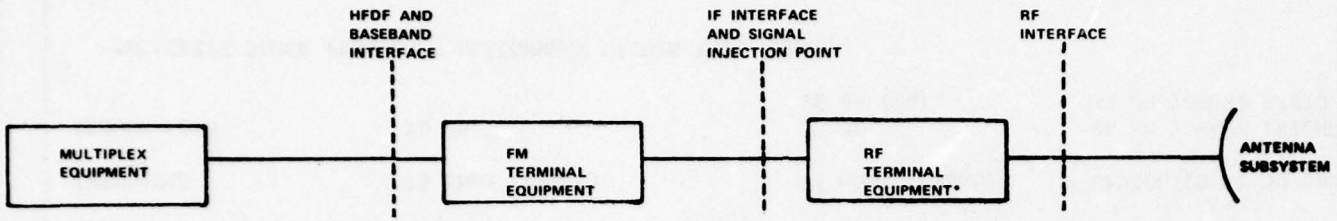
c. If the radio set or transmission line fails to meet specified performance requirements, notify the responsible activity of required corrective actions.



FREQUENCY	12 TO 1364 kHz	70 MHz	MICROWAVE 1700 TO 15,000 MHz*
TEST TONE LEVEL			
TRANSMIT	-45 dBm		
RECEIVE	-15 dBm (±0.5 dB)		
IF INTERFACE & SIGNAL INJECTION POINT			
TRANSMIT		INPUT LEVEL 0.3 VRMS (0.8 dBm ±0.5 dB)	37 dBm (5 WATTS)
RECEIVE		OUTPUT LEVEL 0.625 VRMS (5.2 dBm ±0.5 dB)	-30 dBm NOMINAL (-80 TO -15 dBm RANGE)
IMPEDANCE	75 ohms (UNBAL)	75 ohms (UNBAL)	WAVEGUIDE AT 50 ohms
RETURN LOSS	20 dB	20 dB 26 dB (DO)	28 dB TOWARD ANTENNA 32 dB TOWARD RADIO RCVR

*DISCRETE BLOCK FREQUENCY ASSIGNMENT WITHIN THIS RANGE.

Figure 36-1. Radio interface parameters.



FREQUENCY	12 TO 1340 kHz	70 MHz	MICROWAVE 350 TO 8400 MHz*
TEST TONE LEVEL			
TRANSMIT	-45 dBm		
RECEIVE	-15 dBm (±0.5 dB)		
IF INTERFACE & SIGNAL INJECTION POINT			
TRANSMIT		INPUT LEVEL 0.3 VRMS (0.8 dBm ±0.5 dB)	40 TO 77 dBm (10 WATTS TO 50 kw)
RECEIVE		OUTPUT LEVEL 0.625 VRMS (5.2 dBm ±0.5 dB)	-80 dBm NOMINAL (-97 TO -75 dBm RANGE)
IMPEDANCE	75 ohms (UNBAL)	75 ohms (UNBAL)	WAVEGUIDE AT 50 ohms
RETURN LOSS	20 dB 26 dB (DO)	20 dB 26 dB (DO)	26 dB TOWARD ANTENNA 32 dB TOWARD RADIO RCVR

*DISCRETE BLOCK FREQUENCY ASSIGNMENTS ARE AVAILABLE WITHIN THIS RANGE EXCEPT FOR 7125 TO 8400 MHz WHICH IS PROHIBITED BY ITU AGREEMENTS FOR TROPOSPHERIC SCATTER DEPLOYMENT.

Figure 36-2. System parameters.

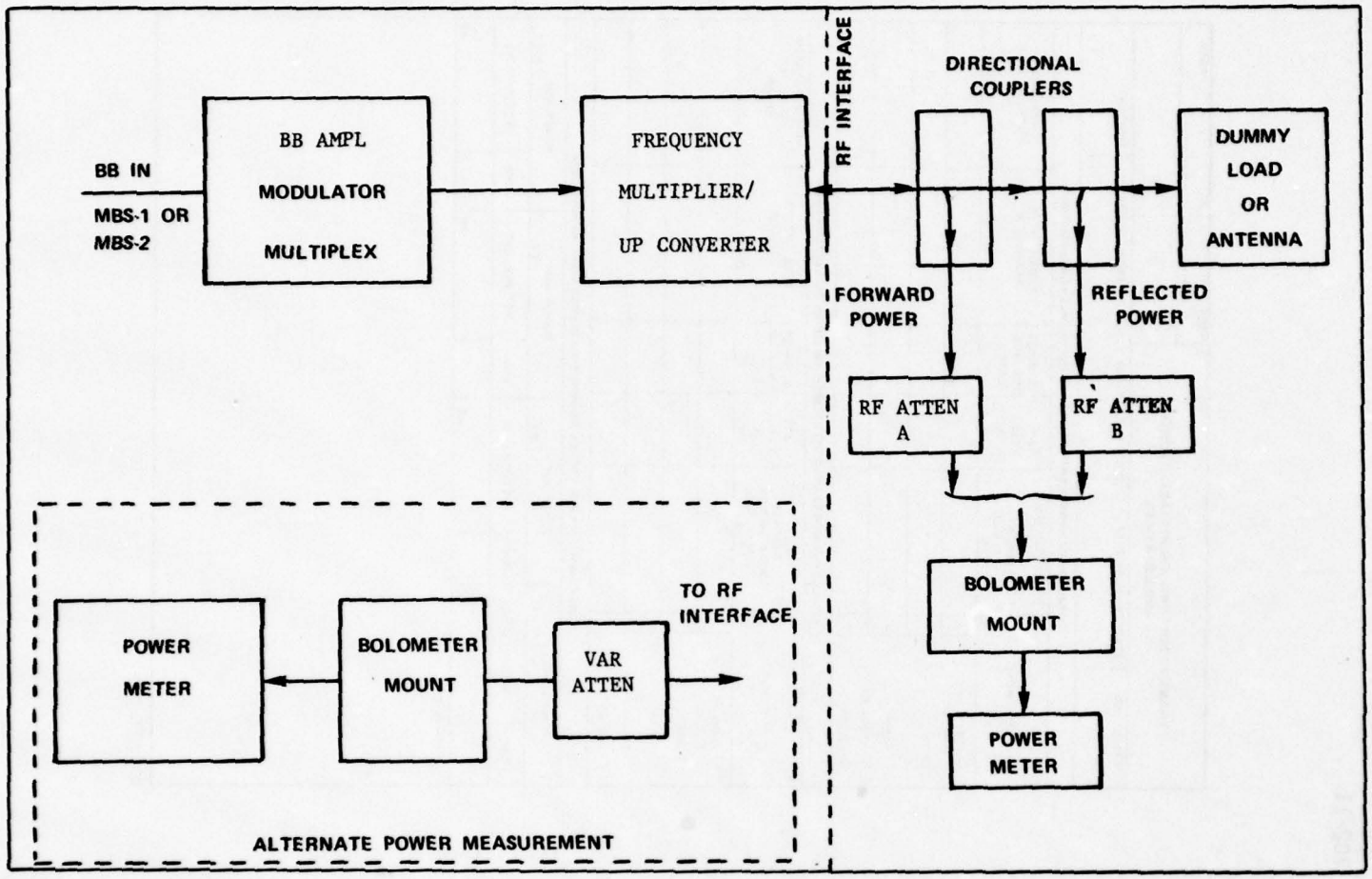


Figure 36-3. Transmitter output power and antenna system reflected power test setup.

TRANSMITTER FORWARD/REFLECTED POWER AND VSWR DATA				PAGE ____ OF ____ PAGES DATE
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INITIAL	TECH. INIT.

HIGH/LOW TRANSMITTER POWER AMPLIFIER OUTPUT FORWARD POWER

EQUIPMENT		DIRECTIONAL COUPLER ATTENUATION VALUE, C dB	ATT VALUE, A dB	CONNECTING LINE LOSS, L dB	POWER METER READING, R dBm	FORWARD (OUTPUT) POWER P_f WATTS
☐ Reflex Klystron	1					
☐ TWT	2					
☐ Exciter	3					
☐ Interim, PA						
☐ Final PA	4					

HIGH/LOW POWER TRANSMITTER POWER AMPLIFIER REFLECTED POWER

EQUIPMENT	DIRECTIONAL COUPLER ATTENUATION VALUE, C dB	ATT VALUE, B, dB	CONNECTING LINE LOSS, L dB	POWER METER READING, R dBm	ANTENNA SYSTEM REFLECTED POWER P_r WATTS
☐ Reflex Klystron					
☐ TWT					
☐ Exciter					
☐ Interim, PA					
☐ Final PA					

POWER AMPLIFIER/HIGH POWER TRANSMITTER OUTPUT VSWR, RETURN LOSS

POWER AMP #1		POWER AMP #2		POWER AMP #3		POWER AMP #4	
VSWR	RETURN LOSS	VSWR	RETURN LOSS	VSWR	RETURN LOSS	VSWR	RETURN LOSS
	dB		dB		dB		dB

COMMENTS:

DD FORM 1 SEP 77 2121

Figure 36-4. Transmitter power output and VSWR data sheet.

CHAPTER 37

TRANSMITTER MODULATOR FREQUENCY DEVIATION AND LINEARITY (DT-234)

37-1. GENERAL.

a. The purpose of this test is to measure the linearity and the limits of linearity of the transmitter modulator peak frequency deviation (ΔF) over the operating range of the modulating signal RMS voltage levels.

b. The transmitter modulator frequency deviation and linearity can be determined by measuring the peak frequency deviation (ΔF) at the transmitted IF or RF signal frequencies.

c. The amount of frequency deviation of the RF carrier determines the amount of amplitude detected by the discriminator of the distant receiver. If the deviation is set too high, the receive baseband levels will be high; conversely, if deviation is set too low, baseband signals will also be low. The amount of deviation will be determined by equipment design which is chosen to provide the best possible SNR and minimum intermodulation in the receive baseband.

d. In order to obtain the RF carrier signal deviation, the measured deviation must be multiplied by a factor k, where k is the frequency multiplication which the signal undergoes between the measuring point and the final RF signal output. However, in systems where the modulated IF deviation is not altered, the peak deviation of the RF carrier signal is identical to the peak deviation of the IF signal.

e. Digital radios will normally differ from analog radios in that preemphasis is not required. As a result, the linearity curves should have approximately the same slope for all values of frequency versus modulating level. In addition, the baseband of the digital radio will extend higher in frequency than the analog radios currently in use. The linearity and deviation should be checked at three frequencies throughout the baseband to ensure that the system is operating properly.

f. In the digital radios, the transmit baseband level will usually be specified in terms of VPP which can be read on an oscilloscope. A sinusoidal wave read on a true RMS voltmeter or an average responding meter with an RMS scale will be 2.8 times the value read on the meter.

g. There are three commonly accepted methods for measuring the frequency deviation (ΔF).

(1) *Microwave link analyzer.* This test instrument accurately measures and conveniently displays the linearity of the frequency deviation. Therefore, if a microwave link analyzer is available, this would be the preferred measurement method.

(2) *Carrier dropout technique.* This is the most commonly used method. It is characteristic of all frequency or phase-modulated radio systems that for certain frequencies of modulating tones the carrier (in the modulated signal) will disappear. This disappearance is due to phase cancellation of certain components produced during modulation and always occurs with mathematical precision. The mathematical relationship describing this phenomenon is termed Bessel functions. The disadvantage of the carrier dropout technique is that relatively few points on the deviation versus signal input curve are obtained unless a low modulating frequency is used. When preemphasis is used in the transmitter, the use of a low frequency modulating signal requires such a high level input signal to reach the limit of deviation linearity that distortion problems may invalidate the test results. To overcome these problems and at the same time provide additional points on the deviation versus signal input level curve, the sideband zero points as well as the carrier zero points can be used. In this way, additional points can be identified and plotted, providing a more valid indication of the linearity.

(3) *Bessel function.* This method consists of frequency modulating the RF carrier with a sinusoidal signal, and measuring and comparing the relative amplitudes of the RF carrier and the sideband components of the resultant spectrum of the frequency modulated RF signal. The Bessel function method is more complex and can be more time-consuming if test personnel are not highly trained.

h. Other methods are available such as delay and linearity test sets and modulation deviation calibrators. However, the method to be used will depend on the availability of test equipment and accuracy required as specified by contract specifications or as directed.

i. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer and quality assurance personnel during onsite test actvities as directed.

j. This test is primarily applicable to the AN/FRC-162 and other FM or modified FM radios for transmission of digital data.

37-2. SPECIFICATIONS.

a. The peak deviation capability of the equipment shall be at least ±7 MHZ. The ratio of carrier deviation to the highest baseband frequency shall be smoothly adjustable between the range of 0.5 and 7.0 MHz. All performance characteristics shall apply when operating at any combination of deviation ratio and peak deviation allowable under the formula for necessary bandwidth when the bandwidth is within the range of 5 to 15 MHz inclusive. (MIL-STD-188-313)

b. The frequency deviation versus input voltage (AN/FRC-162) shall be linear within 1 percent up to a peak deviation of ±5 MHz. (SCCC-73017)

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

37-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. Spectrum analyzer.

c. Voltmeter.

d. True RMS voltmeter.

e. Baseband signal generator/oscillator.

f. Microwave link analyzer, 3710, 3716, 3702B, 3705A, 3730A, 3738A.

g. Frequency counter.

h. Attenuators, as required.

i. Terminators, adapters, and connectors, as required.

37-4. TEST PROCEDURES.

a. Perform the standard alinement procedure for adjusting the transmitter frequency deviation as specified in the equipment technical manual or manufacturer's literature. These alinement procedures determine the normal settings for the modulator input controls in terms of voltage versus frequency.

b. On the AN/FRC-162, insert a -16 dBm, 1-MHz test tone at J45 (modulator A) or J46 (modulator B). This test tone should result in a 3.14-MHz peak deviation if properly adjusted.

c. For the microwave link analyzer delay and linearity method, proceed as follows:

(1) Perform a back-to-back operational check in accordance with the equipment technical literature.

(2) Set the transmitter controls as follows:

(a) Baseband input to internal.

(b) Sweep source to internal.

(c) Sweep width to 10 MHz.

(d) Baseband frequency to 500 (or 555).

(e) Baseband power to desired level (-16 dBm) for the AN/FRC-162.

(3) Set the receiver controls as follows:

(a) Baseband input to internal.

(b) Sweep source to internal.

(c) Baseband frequency to 500 (or 555).

(d) Blanking to off.

(e) Markers to ±5 MHz.

(f) Y1 display to IF.

(g) Y2 to delay.

(4) Connect the test equipment as shown in figure 37-1 and allow approximately 30 minutes for warmup and stabilization.

(5) Connect the radio transmitter RF output at J3 to the down converter input. Tune the down converter to the transmit frequency so that the output of the down converter is 70 MHz. Turn the AFC on and ensure proper tuning. Connect the 70-MHz output of the down converter to the IF input of the receiver.

(6) Connect the baseband plus sweep to the transmitter baseband input, J45 or J46. Adjust the receiver IF attenuator for an on-scale reading of the IF level meter. Verify that the AFC lock lamp lights and the IF uncalibrated light is off.

(7) Set the Y1 control to display the baseband signal and adjust the baseband attenuator to obtain an on-scale reading on the baseband meter. Turn the sweep calibration control slowly clockwise until the markers reach the edge of the trace. Adjust the X-phase shift control until the forward and return traces are superimposed. Turn the blanking switch on.

(8) Calibrate the Y1 trace using the Y1/Y2 calibration switch set to the appropriate percent (usually 1 percent per division) and adjust the Y1 gain to set separation between the double Y1 trace to one division. The Y1 trace is now calibrated for linearity. Turn the Y1/Y2 calibration switch off.

(9) Calibrate the Y2 trace for delay as follows: Turn the set level control fully clockwise and adjust the phase-lock control for an up-scale deflection of the phase-lock/level meter. Readjust the set level control for a reading in the green band of the phase-lock/level meter. Adjust the phase-lock control for a peak reading on the phase-lock/level meter, and if necessary, readjust the set level control for a reading in the green band. Set the difference phase calibration switch to the appropriate nsec-per-division value and adjust the Y2 gain control for a one-division separation of the double Y2 trace. Turn the difference phase calibration switch off. The Y2 trace is now calibrated for group delay.

(10) Photograph the traces on the CRT and mount the photographs on figure 5-2 (DD Form 2093). Enter all appropriate data on figure 37-2 (DD Form 2120) to include the value of linearity, delay slope, and delay parabolic (if any). Modify the forms as necessary. See figure 21-2 for an example of a microwave link analyzer delay and linearity trace.

d. For the carrier dropout method, proceed as follows:

(1) Connect the test equipment as shown in figure 37-3 and allow approximately 30 minutes for warmup and stabilization.

(2) Isolate the transmitter by removing the baseband input to the amplifier/modulator and disable the pilots. Terminate the baseband input into its characteristic impedance (75 ohms for the AN/FRC-162, and 78 ohms for the AN/FRC-( )). If preemphasis is used, ensure that it is connected.

(3) Connect the spectrum analyzer to the transmitter RF output test point. Enter the test point used on figure 37-2 (DD Form 2120). Ensure there are no spurious signals near the center of the unmodulated RF carrier frequency that would interfere with the test results. If spurious signals are noted, they should be investigated and resolved before proceeding with the test.

(4) Remove the termination from the input terminals of the baseband input and connect the generator as shown in figure 37-3. For the AN/FRC-162, adjust the generator to 1 MHz at an output level of 1 VPP. The 1-MHz test tone frequency should be used to set the modulation index using a peak deviation of 3.14 MHz with 1 VPP applied to the baseband input. The manufacturer's literature or equipment technical manual should be consulted in setting the deviation.

(5) Gradually increase the baseband generator level from a minimum value until the carrier signal, as observed on the spectrum analyzer, just disappears. Ensure that this is the minimum input level required for zero carrier level (higher levels of input will also produce zero carrier levels). Record the baseband amplifier/modulator input voltage readings on the data sheet associated with each carrier zero (dropout).

NOTE: Because of frequency deviation distortion, the carrier may not disappear. In this case, measure the modulating signal input level required for minimum carrier level. Record the relative amplitude of the minimum carrier to maximum carrier on figure 3-7 (DD Form 2091).

(6) Continue increasing the modulating signal power until the carrier disappears for the second, third, fourth, etc. time. For each, note and record the input signal level, the order of carrier zero, and the value of the modulation index B (table 37-1). Unless the manufacturer's literature shows otherwise, the linearity should be carried to at least a peak deviation of 5 MHz. In most cases, the deviation linearity of the modulator will be exceeded

before the 3d carrier disappearance when the modulating signal frequency is equal to the pivot frequency. See figure 37-4.

(7) In each carrier dropout, calculate the transmitter frequency deviation from the following formula:

$$\Delta F = B \times F$$

Where:

ΔF = transmitter carrier deviation in kHz
B = modulation index determined from table 37-1
F = modulating signal frequency in kHz

(8) Plot a curve of carrier deviation (ΔF) as measured and calculated in the preceding paragraph versus the modulating RMS sinusoidal voltage to the modulator on figure 37-5 (DCA Form (Test) T29-2). This curve will represent the deviation characteristics of the FM transmitter modulator under test. The curve will also show where the equipment approaches the nonlinear region.

(9) Draw a straight line which best fits the plotted data as shown in figure 37-4. Estimate the variation of deviation from linearity (δF) and the limit of linearity (ΔF_L) and enter these values on figures 37-2 (DD Form 2120) and 37-5 (DCA Form (Test) T29-2).

(10) Also calculate and record on the data sheets the linearity of the frequency modulator from:

$$\% \text{ modulator linearity} = \frac{(1 - \delta F)}{\Delta F} \times 100$$

e. Repeat the above procedures for other transmitters to be tested.

37-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review all test results for compliance to specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

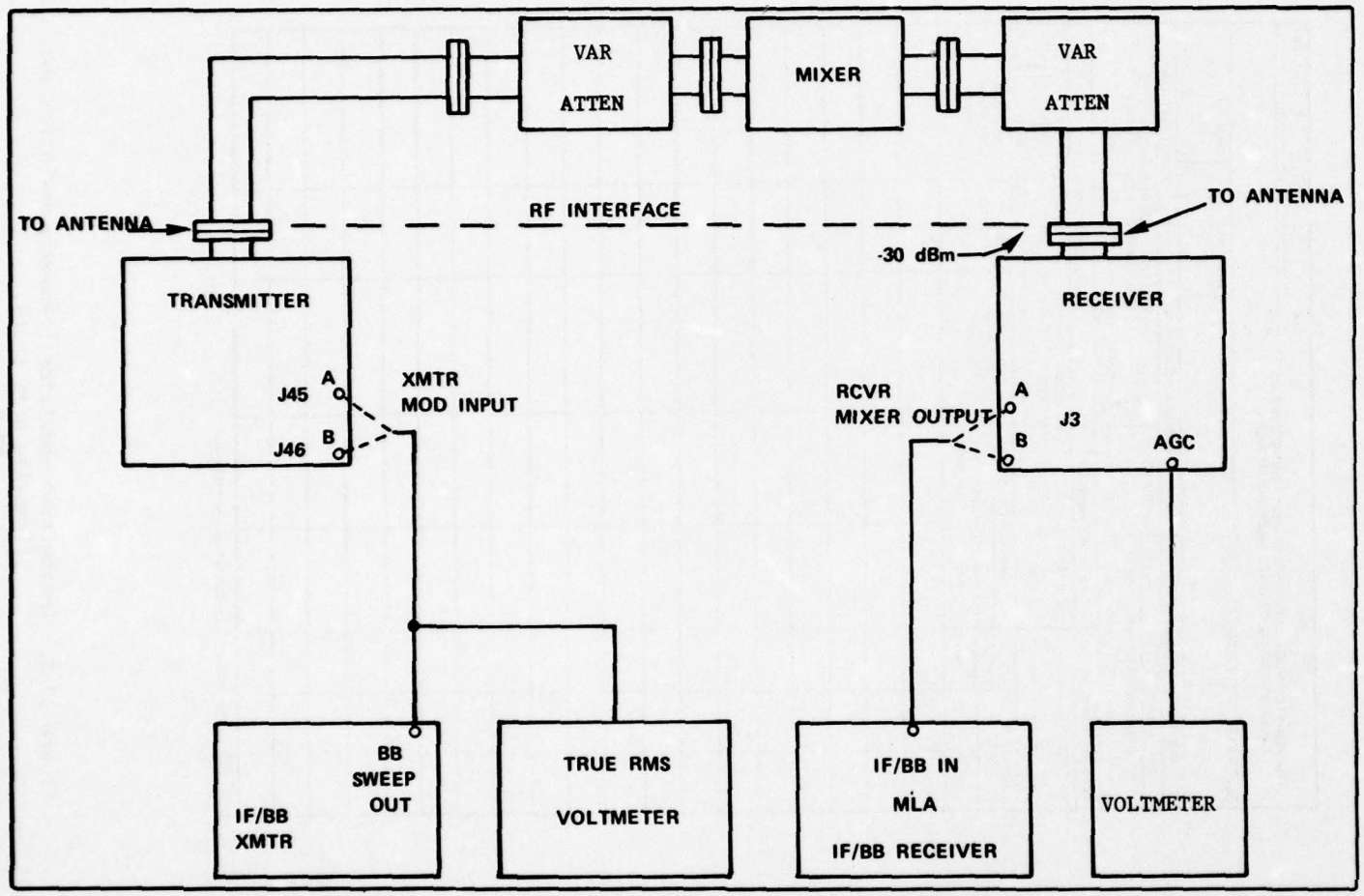


Figure 37-1. Transmitter modulator frequency deviation (MLA) delay and linearity test setup.

TRANSMITTER MODULATOR FREQUENCY DEVIATION AND LINEARITY DATA (CARRIER DROPOUT METHOD)

PAGE _____ OF _____ PAGES

DATE

DCS LINK NO	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECH. INIT.

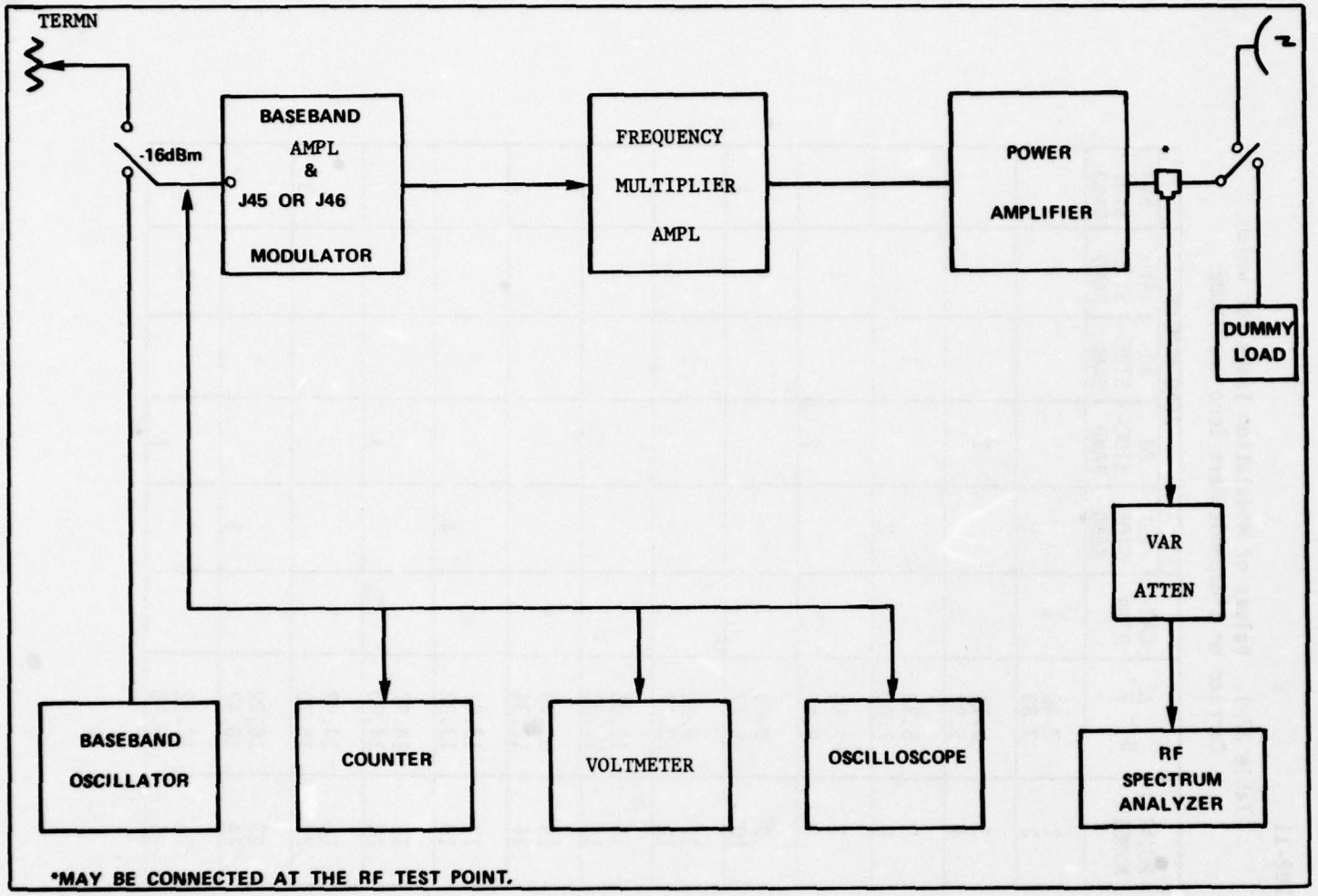
MODULATOR BEING TESTED	BB AMPL./MODULATOR INPUT			OUTPUT TEST POINT
☐ ORDER WIRE ☐ LF ☐ HF HF BASEBAND PIVOT FREQ. _____ kHz	IMPEDANCE _____ OHMS	☐ BAL. ☐ UNBAL.	REF. TEST TONE, dBm0 _____ dBm	☐ MODULATOR OUTPUT ☐ EXCITER OUTPUT ☐ P.A. OUTPUT

DESIGN BB BANDWIDTH	TYPE OF PRE-EMPHASIS	MODULATOR LINEARITY	
NO. OF CHNS: _____ _____ kHz – _____ kHz	☐ 6 dB/OCTAVE ☐ CCIR ☐ OTHER	VAR. FROM LINEAR δF _____ kHz LIMIT OF LINEARITY F_L, _____ kHz	LINEARITY _____ % $\left(1-\frac{\delta F}{\Delta F_L}\right)\times 100$

ORDER OF ZERO		MOD. INDEX (β)	MODULATING SIGNAL		XMTR CARRIER DEVIATION ΔF, (kHz)	MULT. FACTOR (K)	RF SIGNAL DEVIATION (kHz)
CXR	___SB		FREQUENCY (hKz)	INPUT LEVEL (mV, RMS)			

DD FORM 1 JUNE 78 2120 PREVIOUS EDITON SHOULD NOT BE USED

Figure 37-2. Transmitter modulator frequency deviation and linearity data sheet.



37-9

CCP 702-11

Figure 37-3. Carrier dropout test setup.

Table 37-1. Values of Modulation Index for which Carrier or Sidebands Have Zero Amplitude

POINT NUMBER	$\beta = \frac{\Delta F}{f}$	CAR-RIER	ZERO NUMBER				
			1st SIDE-BAND	2d SIDE-BAND	3d SIDE-BAND	4th SIDE-BAND	5th SIDE-BAND
1	2.40	1					
2	3.83		1				
3	5.14			1			
4	5.52	2					
5	6.38				1		
6	7.02		2				
7	7.59					1	
8	8.42			2			
9	8.65	3					
10	8.77						1
11	9.76				2		
12	10.17		3				
13	11.06					2	
14	11.62			3			
15	11.79	4					
16	12.34						2
17	13.02				3		
18	13.32		4				
19	14.37					3	
20	14.80			4			
21	14.93	5					
22	15.70						3
23	16.22				4		
24	16.47		5				
25	17.62					4	
26	17.96			5			

Table 37-1. Values of Modulation Index for which Carrier or Sidebands Have Zero Amplitude (continued)

POINT NUMBER	$\beta = \frac{\Delta F}{f}$	CAR-RIER	ZERO NUMBER				
			1st SIDE-BAND	2d SIDE-BAND	3d SIDE-BAND	4th SIDE-BAND	5th SIDE-BAND
27	18.08	6					
28	18.98						4
29	19.41				5		
30	19.62		6				
31	20.83					5	
32	21.12			6			
33	21.21	7					
34	22.21						5
35	22.58				6		
36	22.76		7				
37	24.02					6	
38	24.27			7			
39	24.35	8					
40	25.43						6
41	25.75				7		
42	25.90		8				
43	27.20					7	
44	27.42			8			
45	27.49	9					
46	28.63						7
47	28.91				8		
48	29.04		9				
49	30.37					8	
50	30.57			9			
51	30.63	10					

TRANSMITTER MODULATOR FREQUENCY DEVIATION

PAGE _____ OF _____ PAGES

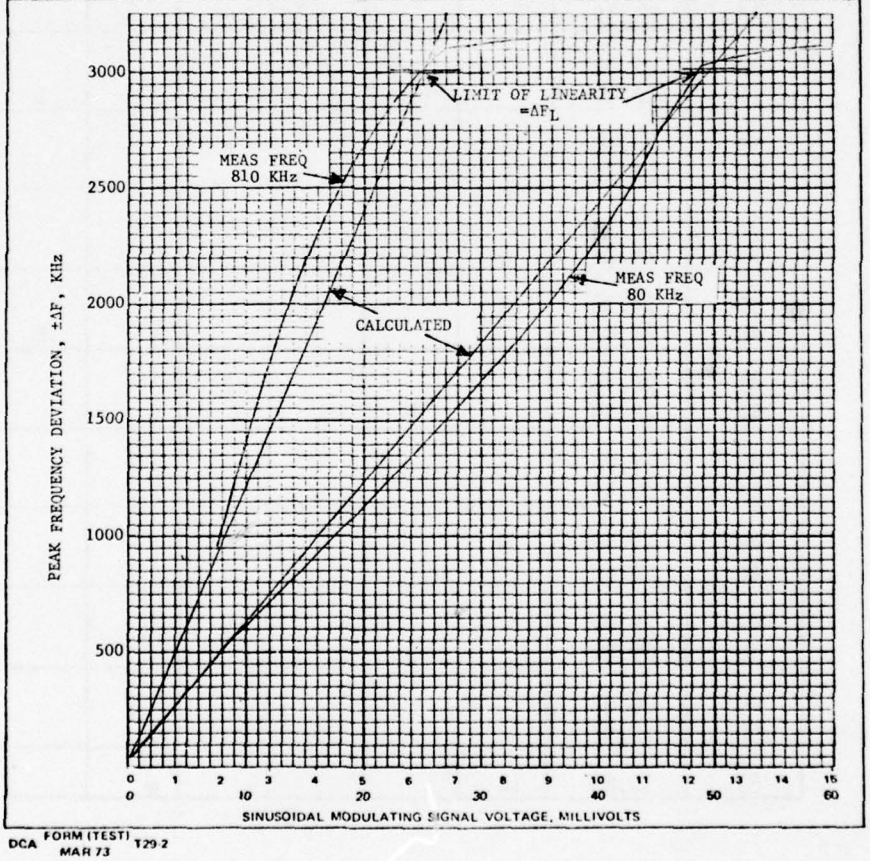
DATE (day, mo., year)

DATA SHEET T29-2

STATION UNDER TEST	TYPE OF PRE-EMPHASIS	TEST ENGR. SIGNATURE
	☐6 dB/OCTAVE ☐CCIR ☐OTHER	

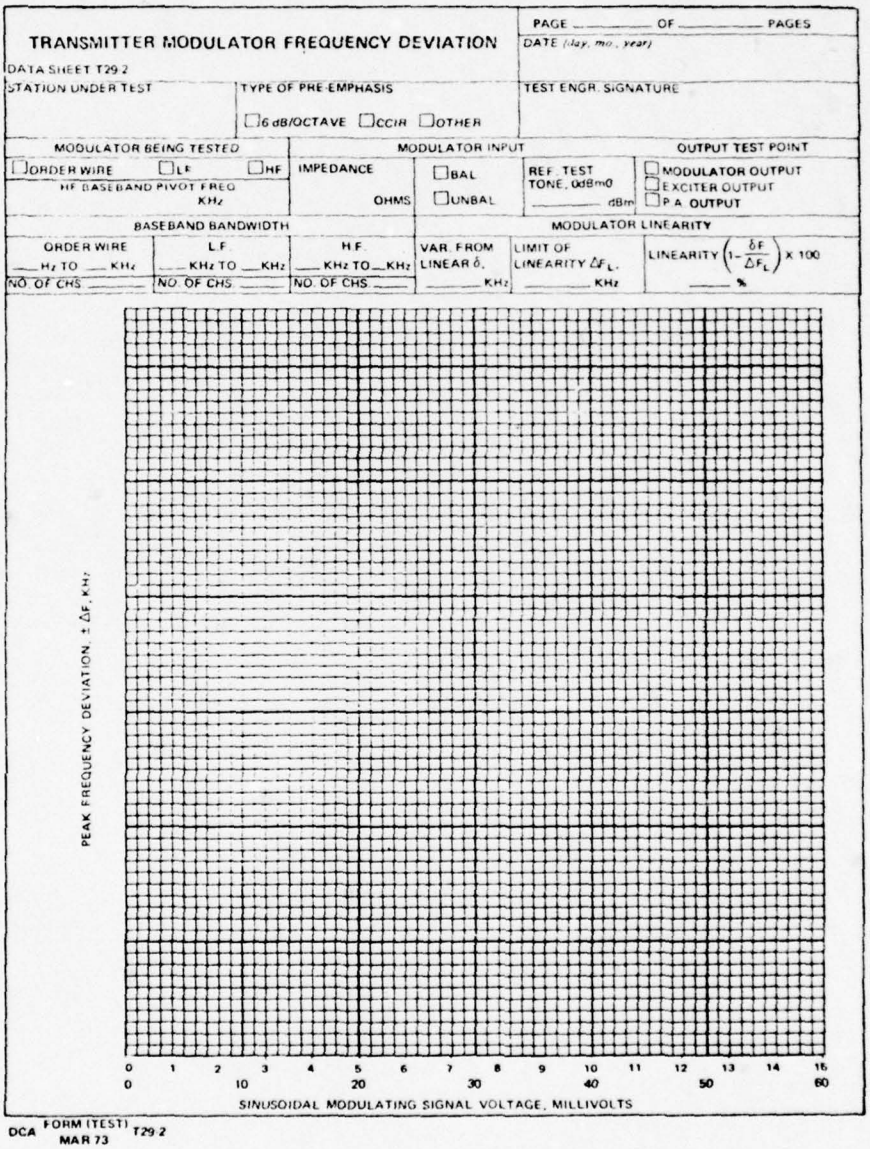
MODULATOR BEING TESTED	MODULATOR INPUT			OUTPUT TEST POINT
☐ORDER WIRE ☐LF ☐HF	IMPEDANCE	☐BAL	REF. TEST TONE, 0dBm0	☐MODULATOR OUTPUT
HF BASEBAND PIVOT FREQ KHz	OHMS	☐UNBAL	_____ dBm	☐EXCITER OUTPUT ☐P.A. OUTPUT

BASEBAND BANDWIDTH			MODULATOR LINEARITY		
ORDER WIRE	L.F.	H.F.	VAR. FROM LINEAR δ,	LIMIT OF LINEARITY ΔF_L,	LINEARITY $\left(1-\frac{\delta F}{\Delta F_L}\right)$ X 100
___ Hz TO ___ KHz	___ KHz TO ___ KHz	___ KHz TO ___ KHz	_____ KHz	_____ KHz	_____ %
NO. OF CHS. _____	NO. OF CHS. _____	NO. OF CHS. _____			



DCA FORM (TEST) MAR 73 T29-2

Figure 37-4. Typical delay and linearity curves.



TRANSMITTER MODULATOR FREQUENCY DEVIATION

PAGE _____ OF _____ PAGES

DATE (day, mo., year)

DATA SHEET T29.2

STATION UNDER TEST	TYPE OF PRE-EMPHASIS	TEST ENGR. SIGNATURE
	☐6 dB/OCTAVE ☐CCIR ☐OTHER	

MODULATOR BEING TESTED			MODULATOR INPUT			OUTPUT TEST POINT
☐ORDER WIRE	☐LF	☐HF	IMPEDANCE	☐BAL	REF. TEST TONE, 0dBm0	☐MODULATOR OUTPUT
HF BASEBAND PIVOT FREQ. KHz			OHMS	☐UNBAL	_____ dBm	☐EXCITER OUTPUT ☐P.A. OUTPUT

BASEBAND BANDWIDTH			MODULATOR LINEARITY		
ORDER WIRE	L.F.	H.F.	VAR. FROM LINEAR δ,	LIMIT OF LINEARITY ΔF_L,	LINEARITY $\left(1-\frac{\delta F}{\Delta F_L}\right) \times 100$
___ Hz TO ___ KHz	___ KHz TO ___ KHz	___ KHz TO ___ KHz	_____ KHz	_____ KHz	_____ %
NO. OF CHS _____	NO. OF CHS _____	NO. OF CHS _____			

PEAK FREQUENCY DEVIATION, ± ΔF, KHz

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

0 10 20 30 40 50 60

SINUSOIDAL MODULATING SIGNAL VOLTAGE, MILLIVOLTS

DCA FORM (TEST) MAR 73 T29.2

Figure 37-5. Transmitter modulator frequency deviation (graph) data sheet.

CHAPTER 38

TRANSMITTER DEMODULATOR LINEARITY (DT-235)

38-1. GENERAL.

a. The purpose of this test is to measure the linearity of the radio set demodulator.

b. This test applies primarily to FM radios and the AN/FRC-162 modified for digital applications.

c. This test may be performed on contractor EF&I systems to ensure that they conform to specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

38-2. SPECIFICATIONS.

a. The output of the AN/FRC-162 demodulator, as a function of the peak deviation of the input signal, shall be linear within 1 percent over the IF between 65 and 75 MHz. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

38-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. AF/RF sweep generator.

c. Frequency counter.

d. Turnaround mixer.

e. Frequency selective voltmeter.

f. Voltmeter.

g. Microwave link analyzer.

h. Attenuators, adapters, and connectors, as required.

38-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 38-1 and allow approximately 30 minutes for warmup and stabilization.

b. If the radios are not tuned to the same frequency, use a turnaround mixer to translate the transmitter RF output frequency to the assigned

receiver frequency. Adjust AT-2 to provide a safe operating level into the mixer, and adjust AT-2 to provide an RSL of -30 dBm.

c. Insert a -16 dBm, 1-MHz test tone from the AF/RF generator into the transmitter modulator input. This test tone should cause a peak deviation of 3.14 MHz providing the transmitter has been properly alined.

d. At the receive baseband (receiver switch out (J2)), measure and record the test tone level. If the measured level is not +2.2 dBm (1 VPP), verify the transmit and receive levels at the various test points within the equipment and perform a radio alinement before proceeding with the test.

e. Connect the test equipment as shown in figure 38-2.

f. Connect the microwave link analyzer transmitter output to the 70-MHz input of the equalizer module. Disconnect the coaxial cable from J3 of the mixer amplifier. Connect the microwave link analyzer transmitter at this test point.

g. Adjust the microwave link analyzer output for -10 dBm and adjust the controls as follows:

(1) Transmitter.

(a) Baseband input to internal.

(b) Sweep source to internal.

(c) Sweep width to 10 MHz.

(d) Baseband frequency to 500 (or 555).

(e) Baseband power to -10 dBm.

(2) Receiver.

(a) Baseband input to internal.

(b) Sweep source to internal.

(c) Baseband frequency to 500 (or 555).

(d) Blanking to off.

(e) Markers to ±5 MHz.

(f) Y1 to IF.

(g) Y2 to delay.

h. Tune the microwave link analyzer down converter to 70 MHz and turn the AFC on. Connect the receiver IF output J5 or J6 to the IF input of the microwave link analyzer receiver.

i. Connect the microwave link analyzer baseband plus sweep to the equalizer module as outlined in paragraph 38-4f, above. Adjust the microwave link analyzer receiver IF attenuator for an on-scale reading of the IF level meter. Verify that the AFC lock lamp is illuminated and the IF uncalibrated light is off.

j. Set the microwave link analyzer Y1 control to display the IF output signal and adjust the attenuator to obtain an on-scale reading on the baseband meter. Turn the sweep calibration control slowly clockwise until the markers just reach the edge of the trace. Adjust the X-phase shift control until the forward and return traces are superimposed. Turn the blanking switch on.

k. Calibrate the Y1 trace using the Y1/Y2 calibration switch set to the appropriate percent (usually 1 percent per division). Adjust the Y1 gain to set separation between the double Y1 trace to one division. The Y1 trace is now calibrated for linearity. Turn the Y1/Y2 calibration switch off.

l. Calibrate the Y2 trace for delay as follows: Turn the set level control fully clockwise and adjust the phase-lock control for an up-scale deflection of the phase-lock/level meter. Readjust the set level control for a reading in the green band of the phase-lock/level meter. Adjust the phase-lock control for a peak reading on the phase-lock/level meter, and if necessary, readjust the set level control for a reading in the green band. Set the difference phase calibration switch to the appropriate nsec-per-division value and adjust the Y2 gain control for a one-division separation of the double Y2 trace. Turn the difference phase calibration switch off. The Y2 trace is now calibrated for group delay.

m. Photograph the traces on the microwave link analyzer and mount the photographs on figure 5-2 (DD Form 2093). Enter all appropriate data on figure 3-7 (DD Form 2091) to include the value of linearity, delay slope, and delay parabolic, if applicable.

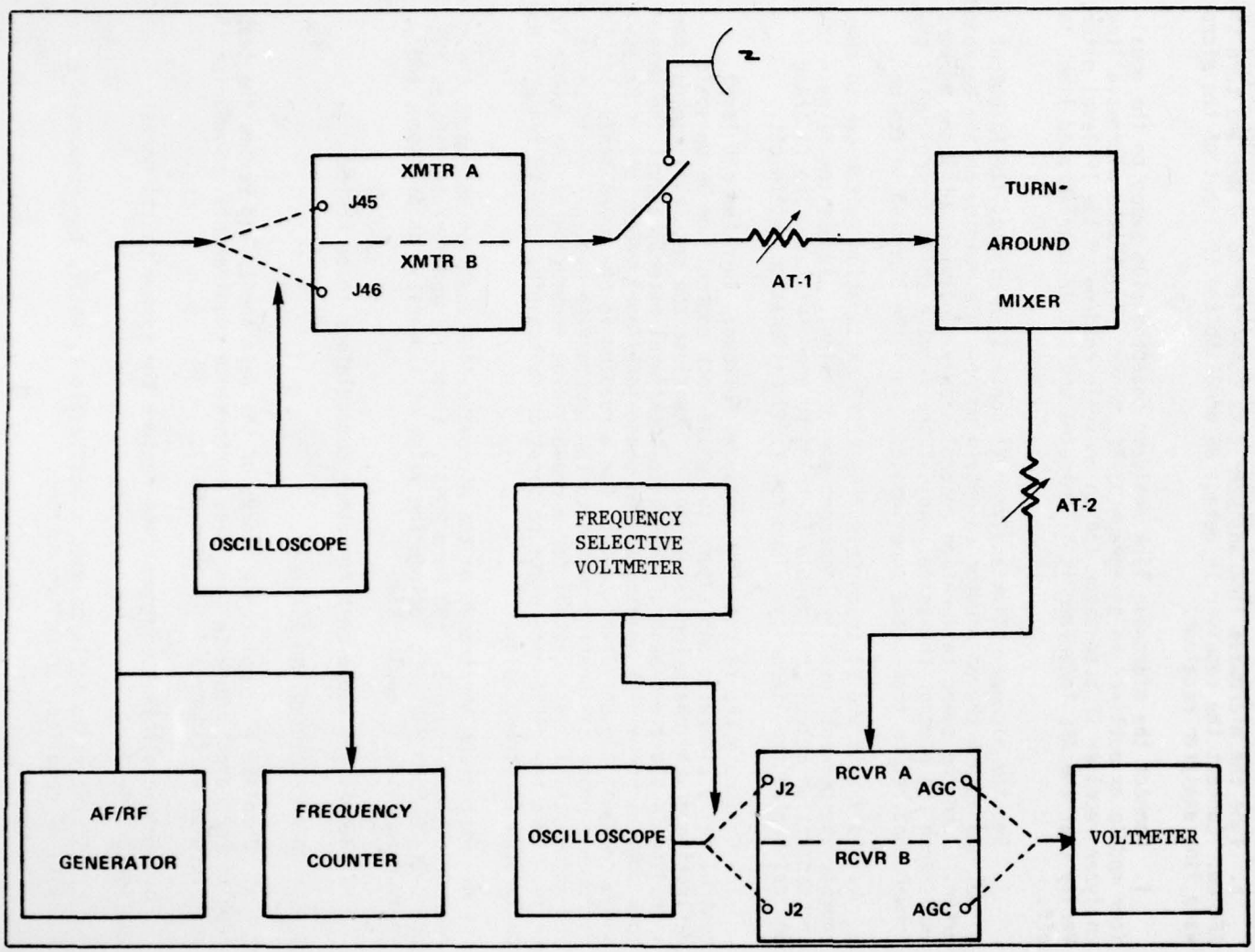
n. Repeat the above test for other demodulators to be tested.

38-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheets and review the test results for compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specifications, notify the responsible activity of required corrective actions.



CCP 702-11

Figure 38-1. Demodulator alinement verification test setup.

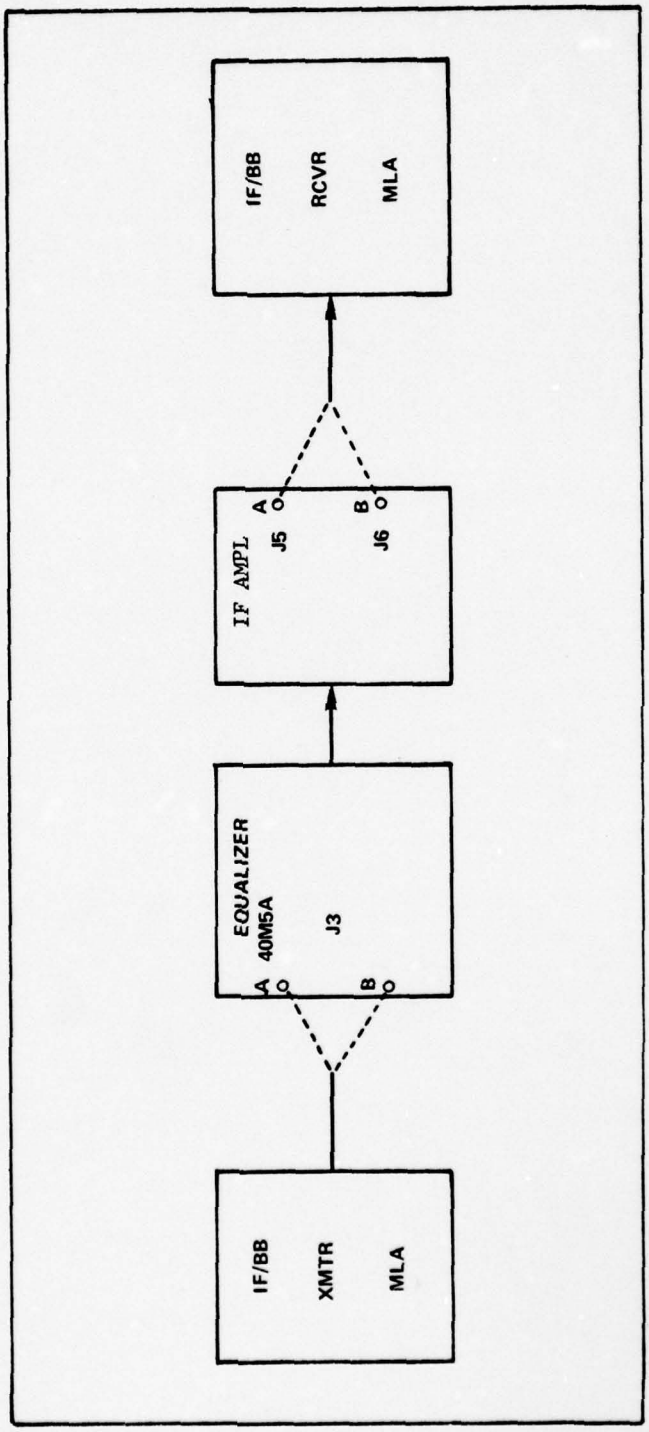


Figure 38-2. Demodulator linearity test setup.

TRANSMITTER FREQUENCY ACCURACY AND STABILITY (DT-236)

39-1. GENERAL.

a. The purpose of this test is to measure the frequency and stability of the radio transmitter RF carrier frequency.

b. The actual transmitter output frequency should be measured whenever possible; however, if the final output frequency is not accessible, the master oscillator output can be measured and the final frequency obtained by multiplying and calculating the transmit frequency.

c. Transmitter frequency accuracy and stability are usually given in relation to the range of temperature and humidity at which the equipment will maintain the specific tolerance. Therefore, measurement of this parameter under field conditions would not generally be satisfactory nor would it provide data that could be compared to the original specifications. It will, however, provide an indication of the accuracy and stability under environmental conditions in which the transmitter is installed.

d. A number of methods are used by the various manufacturers to maintain the transmitter frequency within specified tolerance. Two of the most common methods are AFC and phase-lock loop circuitry. These circuits detect changes in the transmitter frequency and automatically apply the correcting voltage to the oscillator circuit.

e. This test is applicable to the AN/FRC-162 and the AN/FRC-( ).

f. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer and quality assurance personnel during onsite test activities as directed.

39-2. SPECIFICATIONS.

a. The transmitter shall have a frequency stability better than 0.0005 percent (5×10^{-6}) with respect to the assigned RF carrier. (MIL-STD-188-322)

b. The center frequency of the transmitter (AN/FRC-162) shall not vary more than ±150 kHz from the assigned frequency over a period of 90 days without realinement, under the operating conditions shown in table 39-1. This stability shall be obtained within 60 minutes after the application of prime power. (SCCC-73017)

c. The transmitter output frequency (AN/FRC-( )) shall remain constant within 5×10^{-6} over any 60-day period. This requirement shall be met within 1 hour of the initial application of power under all the operating and environmental conditions contained in table 39-2. (CCC-74049)

Table 39-1. Operating Conditions (AN/FRC-162)

PARAMETER	OPERATING	NONOPERATING
Temperature (°C)	0 to 50	-40 to 70
Relative Humidity (%)	0 to 95	0 to 100
Elevation (ft MSL)	0 to 15,000	0 to 40,000

Table 39-2. Operating Conditions (AN/FRC-( ))

PARAMETER	OPERATING	NONOPERATING
Temperature (°C)	0 to 49	-40 to 68
Relative Humidity (%)	Up to 95	Up to 95
Elevation (ft MSL)	Up to 15,000	

d. The criteria for center frequency of the radiated signal in a real section from any transmitter are as follows: (MIL-STD-188-313)

(1) Transmitters which operate with internal carrier generation shall be within 0.0001 percent ($1x10^{-6}$) of the assigned frequency.

(2) Transmitters which depend upon the received signal for establishing the reference signal for the transmitted signal such as in heterodyne repeaters shall be within 0.0001 percent ±0.07 kHz of the received signal.

(3) The cumulative frequency error for a real section shall not exceed 0.0001 percent ±0.07 times N kHz, where N is the number of heterodyne repeaters in a real section.

e. The radio shall operate as specified in the standard engineering plan or contract specifications.

39-3. TEST EQUIPMENT REQUIRED.

a. Directional coupler, as required.

b. Frequency counter.

c. Digital recorder.

d. Digital-to-analog converter.

e. RF sweep generator.

f. Chart recorder.

g. Environmental chamber.

h. Temperature and humidity sensors and converters.

i. Programmable calculator.

j. Adapters, connectors, and cables, as required.

39-4. TEST PROCEDURES.

a. Disconnect all modulation inputs to the transmitter and connect the test equipment as shown in figure 39-1. Allow approximately 30 minutes for warmup and stabilization.

b. If the transmitter employs an AFC circuit, ensure that the AFC is activated. Insert an unmodulated drive signal at the correct level and test point when removal of the normal input signal from the transmitter eliminates the drive signal.

c. Complete the top portion of figure 19-2 (DD Form 2102). Record the assigned transmitter frequency. Also record the humidity, temperature, and maximum frequency deviation in the comments section of the data sheet.

d. The two basic methods of measuring and recording the transmitter frequency accuracy are as follows:

(1) *Short-term sampling.* This test will be performed under existing environmental conditions and in an operational configuration.

(a) Couple the frequency counter input to the RF test point. If a test point is not available, insert a directional coupler at the RF interface point as shown in figure 39-1.

(b) Adjust the frequency counter until the transmitter carrier frequency is indicated and the display is stable.

(c) Record the time-varying transmitter frequency on the digital printer for a minimum of 15 minutes. Adjust the recorder and frequency counter to provide for a 10-second printout of the measured frequency. A longer sampling period may be used if required.

(d) Determine the average measured frequency from the recorded data and compute the frequency accuracy using the following formula:

$$A = \frac{(F_C - F_{med})}{F_C} \times 100 \text{ percent}$$

Where:

A = transmitted carrier frequency accuracy
F_C = assigned carrier frequency
F_{med} = measured average carrier frequency

(e) Record the frequency accuracy on the data sheet.

(2) *Long-term measurement.* This type measurement is more applicable at a contractor's facility to determine that the equipment being delivered meets specified performance.

(a) Connect the test equipment as shown in figure 39-1. Calibrate the stripchart recorder to reflect the expected variations of the transmitted frequency. As an example, the calibration for the AN/FRC-162 should be approximately 160 kHz each side of the assigned center frequency. The generator and frequency counter used for calibration and testing must have an accuracy and stability equal to or greater than the radio under test.

(b) Once the stripchart recorder has been calibrated, connect the frequency counter to the RF test point and adjust the counter sensitivity to provide a stable display of the indicated frequency.

(c) Apply primary power to the radio under test. Observe that the transmit frequency stabilizes within 60 minutes and that it is within specified frequency tolerance.

(d) If the test is being performed in an environmental test chamber, periodically change the environmental temperature and humidity while recording the transmitter frequency accuracy and stability in time correlation with the temperature and humidity (tables 39-1 and 39-2). See figure 39-2 for an example of a temperature and humidity profile.

NOTE: Caution should be exercised in changing the relative humidity to ensure that a moisture buildup does not occur.

(e) Record the transmitter frequency, temperature, and humidity based on the contract specifications. For the AN/FRC-162 this would be 90 days. For the AN/FRC-( ) it would be 60 days.

(f) At the conclusion of the recording period, review the recorded data to verify that the radio transmitter frequency stability meets the specified requirements. Record the results on the data sheet.

e. As an alternate method, use the following procedure for short- and long-term recordings (figure 39-3). This method uses an RF frequency counter whose output is fed into a programmable calculator. The calculator can be programed to print out selected information such as number of samples, average frequency deviation, carrier frequency accuracy, low and high excursions, and the median frequency deviation on demand or over the recording period. This method is much more accurate than the preceding method since a large number of samples can be taken over a short period of time. Further, the process of manually reducing the chart recordings will be eliminated.

f. Repeat the above procedures for other radios to be tested.

39-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specifications, notify the responsible activity of required corrective actions.

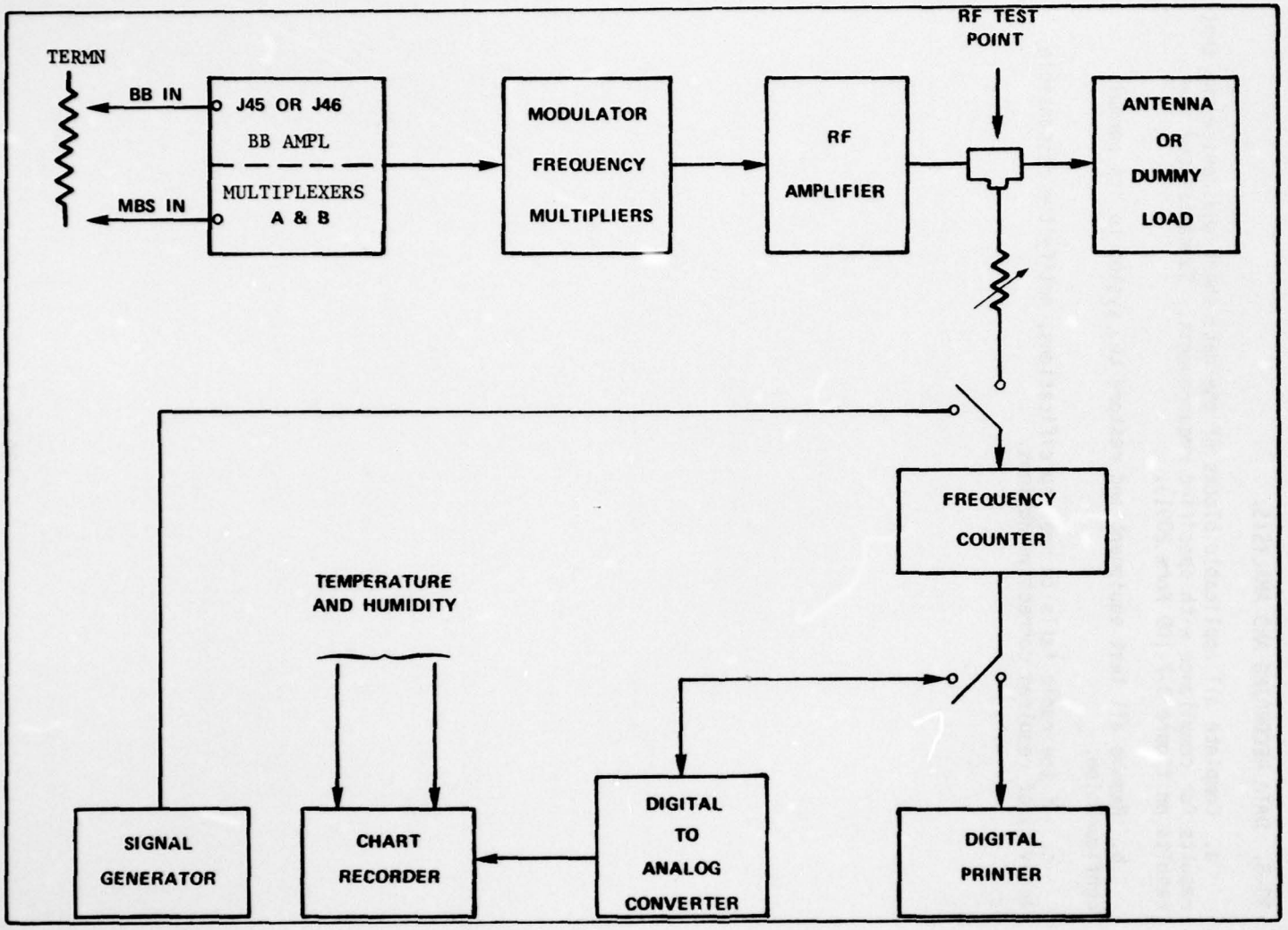


Figure 39-1. Transmitter frequency accuracy and stability (manual) test setup.

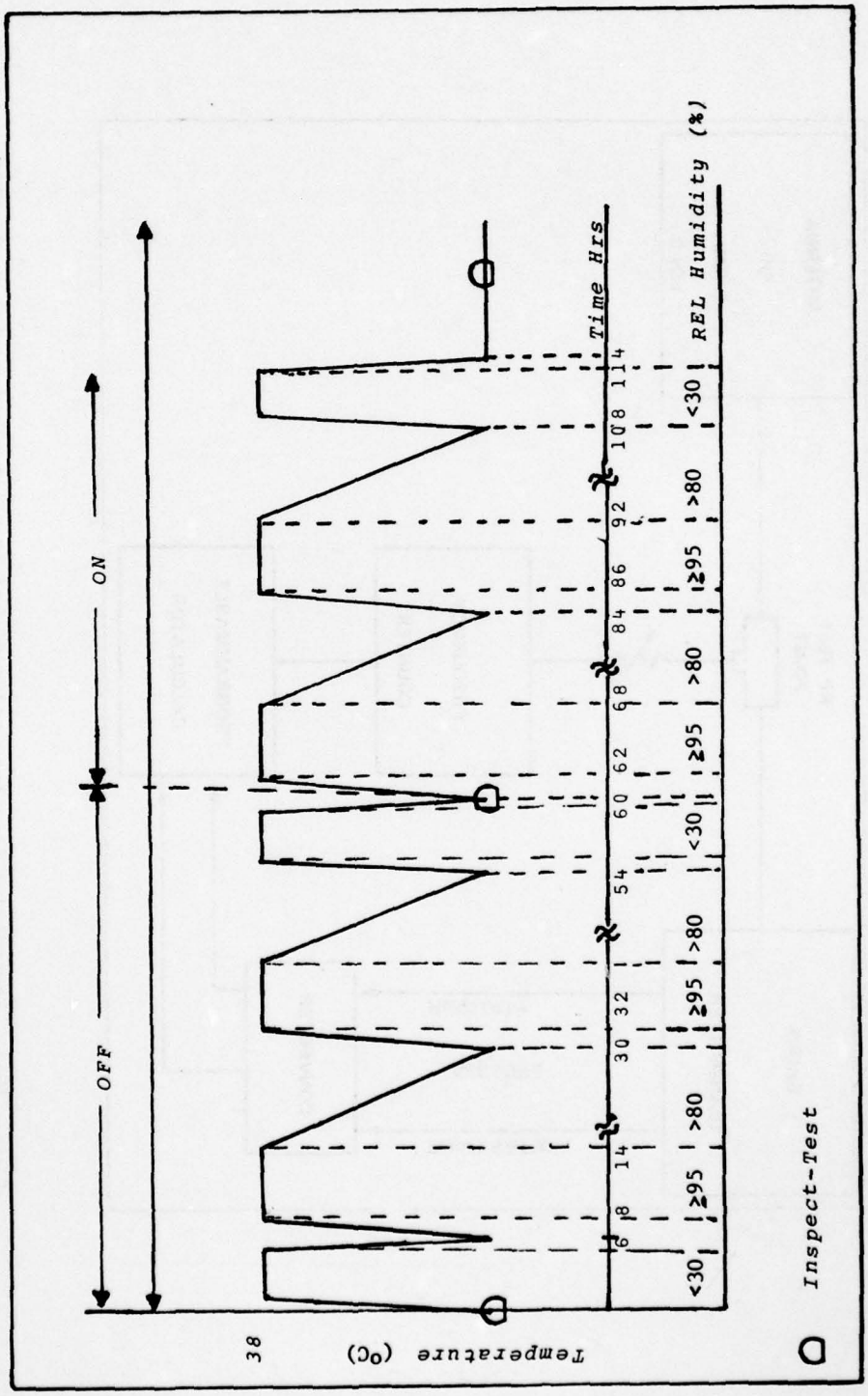


Figure 39-2. Typical temperature-humidity curve.

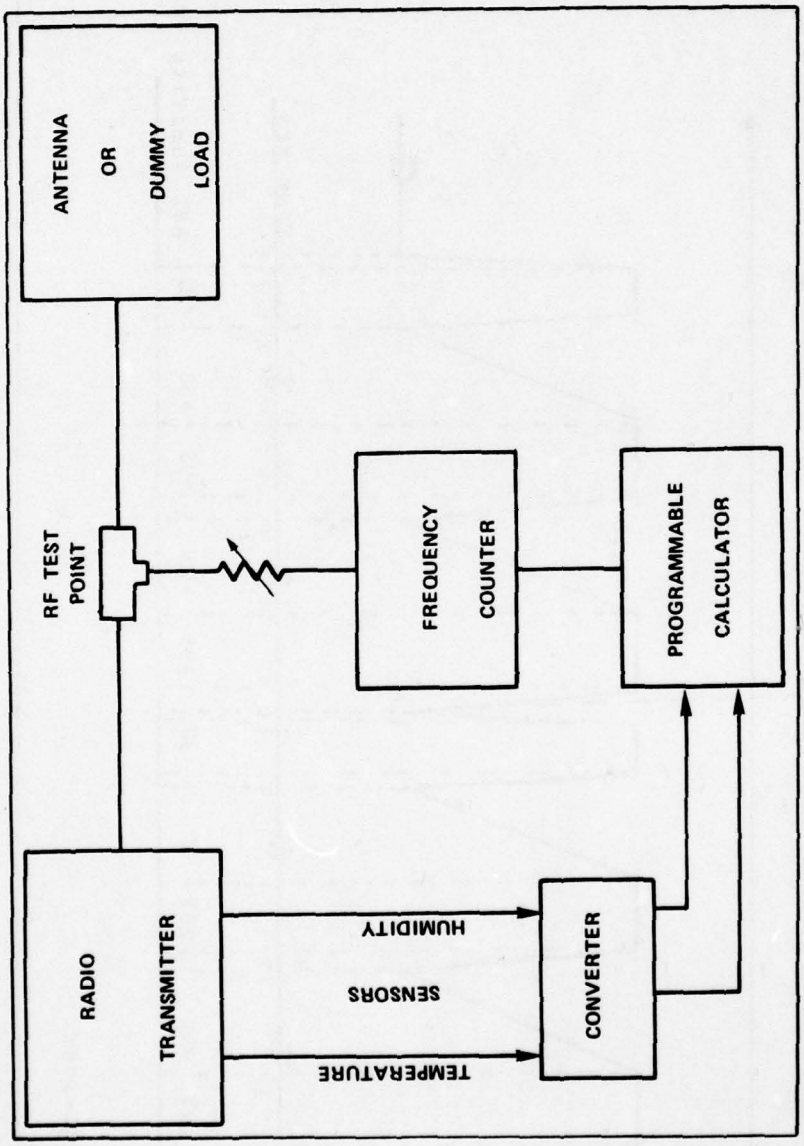


Figure 39-3. Transmitter frequency accuracy and stability (automatic) test setup.

CHAPTER 40

ORDERWIRE SUBCARRIER FREQUENCY DEVIATION (DT-237)

40-1. GENERAL.

a. The purpose of this test is to measure the orderwire subcarrier frequency modulator deviation and receive FM subcarrier demodulator performance.

b. This test is not applicable to the AN/FRC-( ); however, it does apply to the AN/FRC-162 modified for digital operation.

c. This test may be performed on contractor EF&I systems to ensure that they meet specifications. It may also be performed by installer and quality assurance personnel during onsite test activities as directed.

40-2. SPECIFICATIONS.

a. The AN/FRC-162 subcarrier shall be frequency modulated by the input signals in the supervisory baseband spectrum and shall demodulate these signals at the receive end. The peak subcarrier deviation shall be adjustable up to a maximum of 700 kHz. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

40-3. TEST EQUIPMENT REQUIRED.

a. Oscillator.

b. Frequency selective voltmeter.

c. Turnaround mixer.

d. Frequency counter.

e. Voltmeter.

f. Spectrum analyzer.

40-4. TEST PROCEDURES. Connect the test equipment as shown in figure 40-1 and allow approximately 30 minutes for warmup and stabilization. If in an RF loop, adjust the RSL for -30 dBm. Repeat these procedures for other radios to be tested.

a. FM Subcarrier Modulator.

(1) Connect the voltmeter to deviation monitor jacks J1 and J2 (ground) on the front panel of the FM modulator. Set the voltmeter to the 3-volt scale or to a scale as close to 3 volts as possible.

(2) Set the test oscillator for 600 ohms impedance and connect the oscillator output to the FM subcarrier of the radio. Adjust the oscillator frequency to 1 kHz at a level of -7 dBm.

(3) If the voltmeter does not read 0.75±0.05 volts, adjust the deviation adjust control (R9) on the module front panel for the correct level.

(4) Disconnect the test oscillator and voltmeter and connect the frequency selective voltmeter to J2-A of the coaxial connector panel.

(5) Tune the frequency selective voltmeter to 8.1 MHz and measure the subcarrier level. If the level does not read -59±1 dBm, adjust the RF output adjust (R40) on the front panel of the subcarrier module for the correct level. Record the results on figure 40-2 (USACC Form 646-R).

(6) As an alternate method perform a carrier drop test using the spectrum analyzer as described in DT-234.

b. FM Subcarrier Demodulator.

(1) Connect the test equipment as shown in figure 40-3.

(2) Insert a -15 dBm, 4-kHz test tone into the supervisory channel input. Ensure that the oscillator impedance has been set to 75 ohms.

(3) Measure the level at the transmitter FM modulator input J2-A and verify that the level is -59 dBm.

(4) Connect the frequency selective voltmeter to the supervisory channel output (J14) and measure the transmitted 4-kHz test tone. The level should be -15±0.5 dBm. If the level is incorrect, connect the frequency selective voltmeter to the FM demodulator output (J37). The frequency selective voltmeter should be in the bridging mode.

(5) Adjust the demodulator output level control for 0 dBm as read on the frequency selective voltmeter.

NOTE: To determine the linearity and response of the demodulator, perform the sweep technique as outlined in DT-234.

40-5. DATA RECORDING AND ANALYSIS.

a. Review all test results to ensure that the radio meets the specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal operation.

c. If the radio fails to meet specifications, notify the responsible activity of required corrective actions.

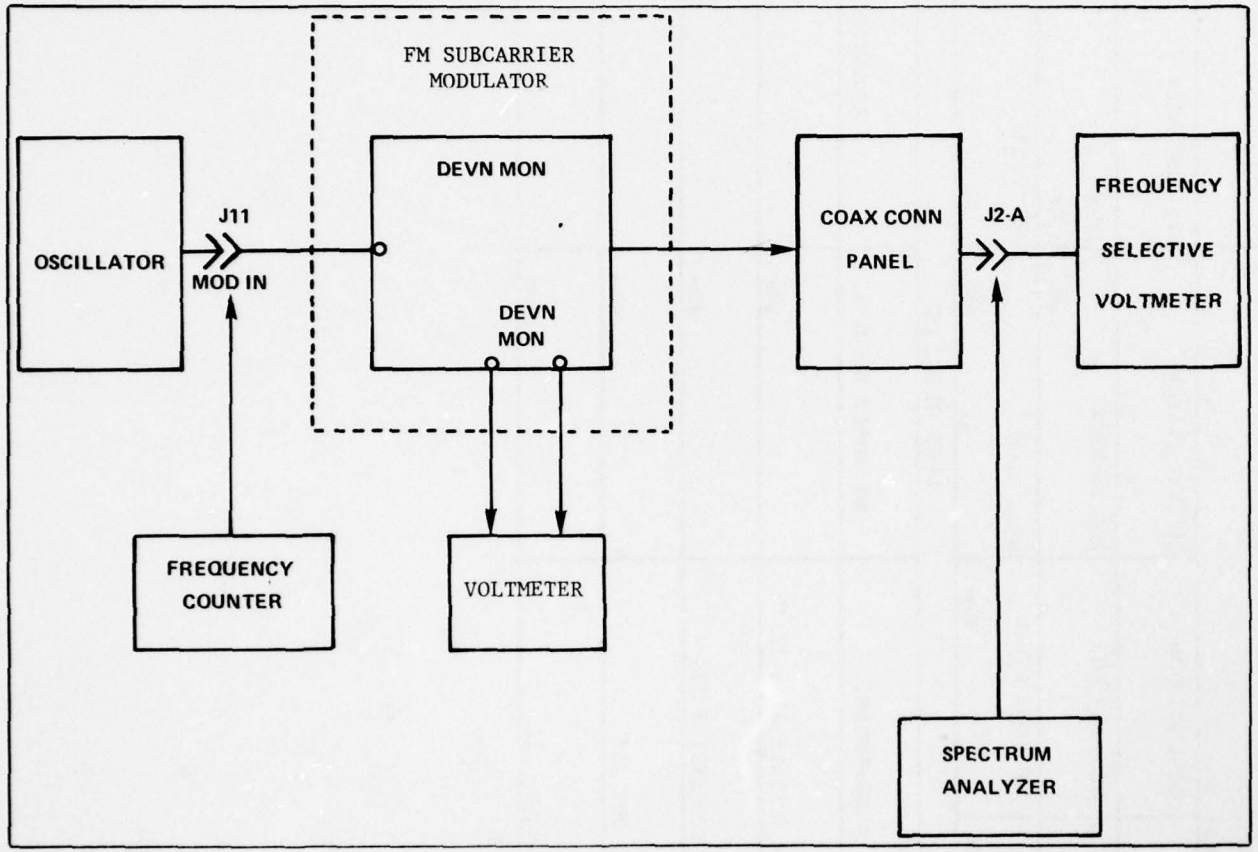
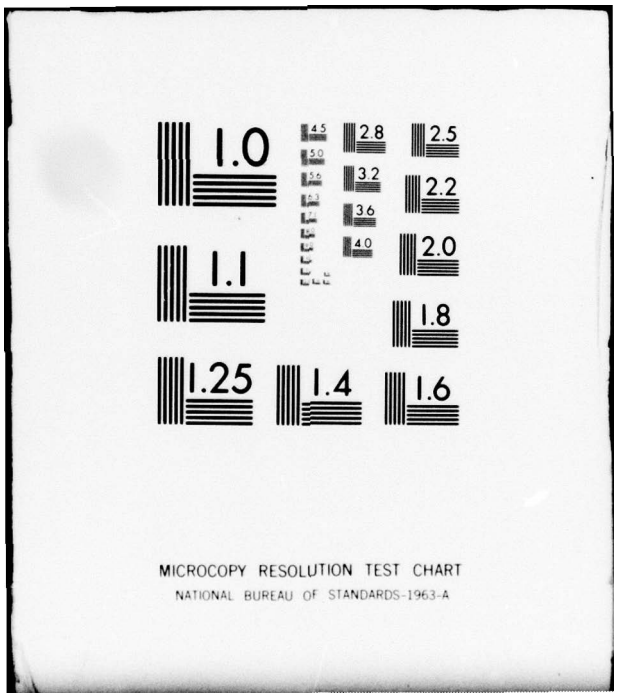


Figure 40-1. Orderwire subcarrier deviation test setup.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

5 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ORDERWIRE SUBCARRIER PERFORMANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	RQR FM DEVN kHz	LINK ☐ LOOP ☐
RSL dBm	TEST TONE LEVEL dBm	MEAS DEVN kHz	AGC VOLTS VDC

TEST RESULTS

MEASUREMENT	MEASURED RESULTS	ADJUSTED TO
DEVN MON VOLTAGE J1 & J2	VDC	VDC
8.1-MHz SUBCARRIER J2A	dBm	dBm
FM DEMOD OUT J37	dBm	dBm
SUPV CHAN OUT J14	dBm	dBm

COMMENTS

USACC FORM 646-R
1 MAY 79

Figure 40-2. Orderwire subcarrier performance data sheet.

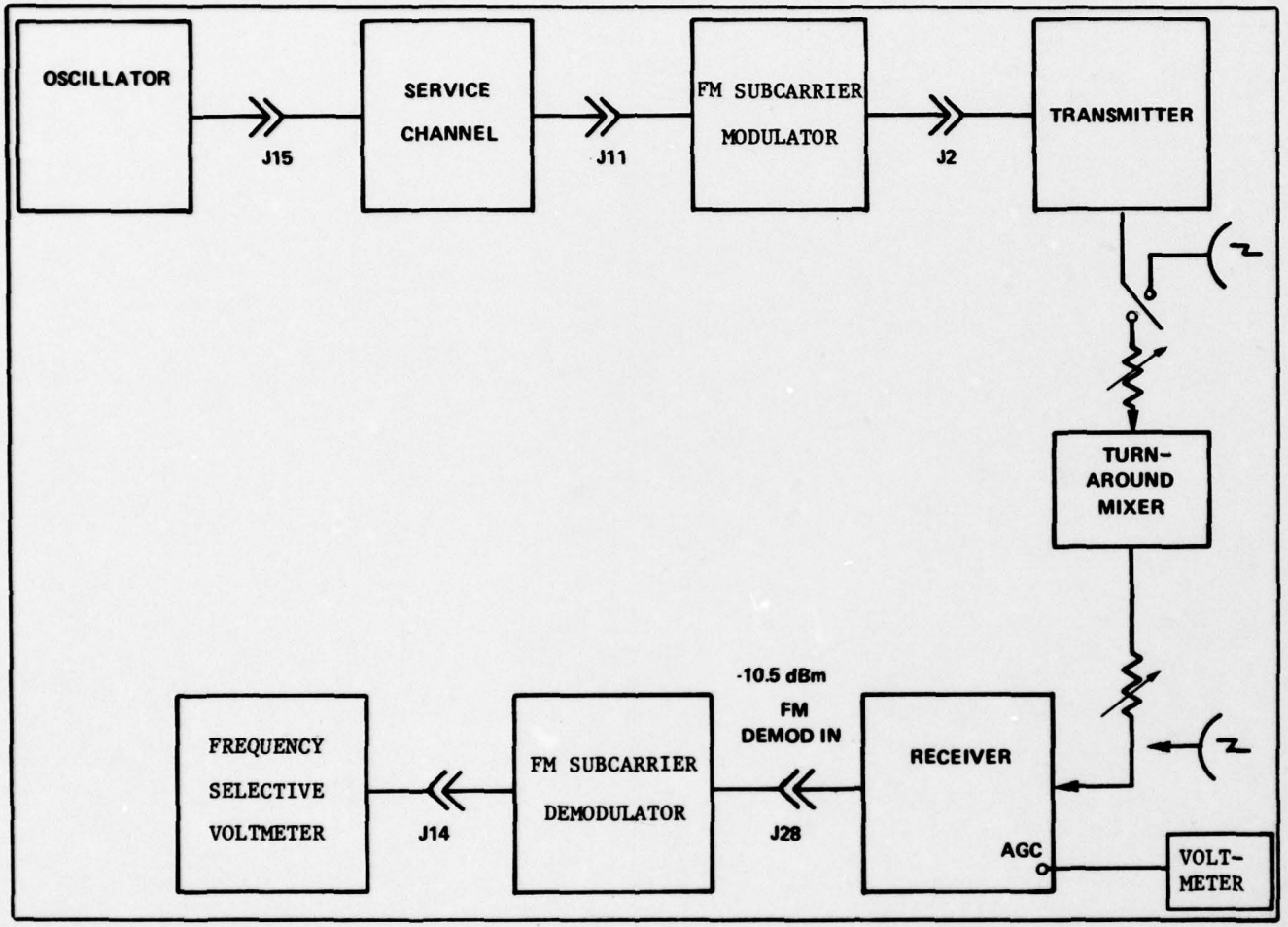


Figure 40-3. FM subcarrier demodulator test setup.

CHAPTER 41

RECEIVER FREQUENCY RESPONSE AND POWER GAIN (DT-238)

41-1. GENERAL.

a. The purpose of this test is to measure the frequency response and gain of the receiver front end from the preselector through the equalizer output.

b. The complete front-end section of the receiver is measured as one unit; however, if the test results are not within specified requirements, individual subsections within the receiver may be tested to isolate the defective subsection. Unless otherwise specified, the 3-dB bandwidth is understood to be between the half-power frequencies where the gain drops 3 dB below the center frequency and is within the required RF spectrum bandwidth.

c. Depending on the equipment design, the receiver front end may include one or more RF amplifier units and a preselector or bandpass filter before or after the RF amplifier. This type of filter may also be known as a waveguide filter, harmonic filter, etc. Where possible, the frequency response and power loss of these filters should also be determined if the overall response of the receiver is not within performance requirements.

d. Where possible, the test signal must be inserted as close as possible to, or at, the RF interface point to ensure that the internal equipment and connectors are included as part of the overall RF amplifier measurement.

e. The test data may be recorded by use of an X-Y recorder, spectrum analyzer, or oscilloscope photographs. The preferred method would be the X-Y recorder since it provides for better quality of the test results and may minimize test time. Although the frequency response and gain test are treated separately in this procedure, the measurements may be made concurrently.

f. This test may be performed on contractor EF&I systems to ensure that they conform to specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

41-2. SPECIFICATIONS.

a. The following criteria applies to the receiver: (MIL-STD-188-313)

(1) The IF bandwidth of the receiver shall be equal to 2.8 $(\Delta F_C + F_m)$.

(2) An LOS receiver shall operate between -80 to -15 dBm. A tropospheric receiver shall operate between -97 to -40 dBm RF input power.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

41-3. TEST EQUIPMENT REQUIRED.

a. X-Y recorder.

b. RF spectrum analyzer.

c. RF counter.

d. RF sweep generator.

e. Oscilloscope camera.

f. RF voltmeter.

g. Crystal detector.

h. Adapter, connectors, and cables, as required.

41-4. TEST PROCEDURES. Repeat these procedures for other receivers to be tested.

a. RF Amplifier Frequency Response.

(1) Connect the test equipment as shown in figure 41-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Complete the top portion of figure 3-4 (DD Form 2094). If using an X-Y recorder, plot the amplitude versus frequency relative to the center frequency on the data sheet.

(3) Set the power output of the RF sweep generator as low as possible. With the sweep signal off (CW), set the frequency of the generator to the center frequency (F_c) of the receiver under test. Use the RF voltmeter to establish a safe power level to the input of the crystal detector.

(4) Starting at a very low power level, gradually increase the input RF power level to the receiver to approximately -60 dBm. This level may have to be changed based on equipment design. Allow for 10-dB attenutation inserted between the output of RF sweep generator and the input to the receiver.

(5) Establish a sweep range from the RF sweep generator sufficiently wide to fully cover the RF amplifier bandwidth to include at least the 6 dB down point.

(6) Sweep the RF amplifier and observe the response on the spectrum analyzer. If satisfactory, the response can then be recorded on the X-Y recorder using figure 3-4 (DD Form 2094).

(7) To calibrate the frequency scale on the X-Y recorder, turn the sweep on the generator to manual. Manually vary the generator frequency in steps across the specified RF signal spectrum and establish the frequency calibration on the horizontal axis of the X-Y recorder chart. Adjust the Y-gain on the recorder to obtain a bandpass similar to that shown in figure 41-2. Mark the center frequency (F_C), the amplitude (A), the baseline (B), and the 3-dB bandwidth (C).

(8) To calibrate the frequency scale on the oscilloscope or spectrum analyzer, disconnect the frequency counter and sweep the frequency of the generator sufficiently to produce a bandwidth in excess of the specified bandwidth of the receiver under test. Use a range of values of the frequency markers from the generator to establish a frequency scale on the analyzer or oscilloscope. Adjust the gain and position controls of the analyzer or oscilloscope so that the pattern baseline (B) and the center frequency (F_C) fall at established reference lines on the display as shown in figure 41-2.

(9) Attenuate the input signal to the receiver under test by 3 dB. Readjust the vertical positioning of the analyzer oscilloscope of the X-Y recorder, if necessary, so that the baseline (B) falls at the original baseline. Mark the positioning level (C) at the point where the dotted curve crosses the center frequency (F_C).

(10) Remove the 3-dB attenuation and reposition the baseline to the original reference. In the X-Y recording, two curves will be displayed on the data sheet, with an amplitude difference of 3 dB, from which values for the 3-dB bandwidth (BW_T) ($F_C - \Delta F$ and $+ \Delta F$) can be determined.

(11) When the frequency scale has been established, use a spectrum analyzer or oscilloscope, if desired, to photograph the curve, making sure that all important levels and marker frequencies are recorded. Mount the photographs on figure 5-2 (DD Form 2093).

NOTE: Consult the equipment technical literature to determine the bandwidth of the RF preselector, filters, and the IF. If this test is performed on the AN/FRC-( ), the wide variations in data rates make it essential that the designed bandwidth be determined before performing the test.

b. Power Gain Measurements.

(1) Connect the test equipment as shown in figure 41-3 using the 1-1 connection.

(2) Set the frequency of the generator (in the CW mode) to the center frequency (F_C) of the receiver under test. Adjust the generator output power to a sufficiently low level to prevent saturation of the RF and IF amplifiers.

(3) Adjust the spectrum analyzer to display the signal at a convenient amplitude. For accuracy, the amplitude should be set to the peak of a known point on the display graticule by marking the position of the peak on the face of the analyzer or oscilloscope.

(4) Note the setting of the output control attenuator of the generator, or variable attenuator, in dB as P_1.

(5) Increase the attenuation of the generator output control by 20 dB.

(6) Switch the connection to the 2-2 position as shown in figure 41-3.

(7) Vary the attenuation of the generator output until the amplitude signal displayed on the spectrum analyzer is the same as noted in subparagraph (3), above. Note the generator attenuator reading, in dB, as P_2.

(8) The power gain, in dB, is the difference between the power noted in subparagraphs (4) and (7), above. That is, $P_1 - P_2$ equals the gain in dB. Record the power gain on the data sheet. If additional space is required, use figure 3-7 (DD Form 2091).

41-5. DATA RECORDING AND ANALYSIS.

a. Review all test data for accuracy, completeness, and compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

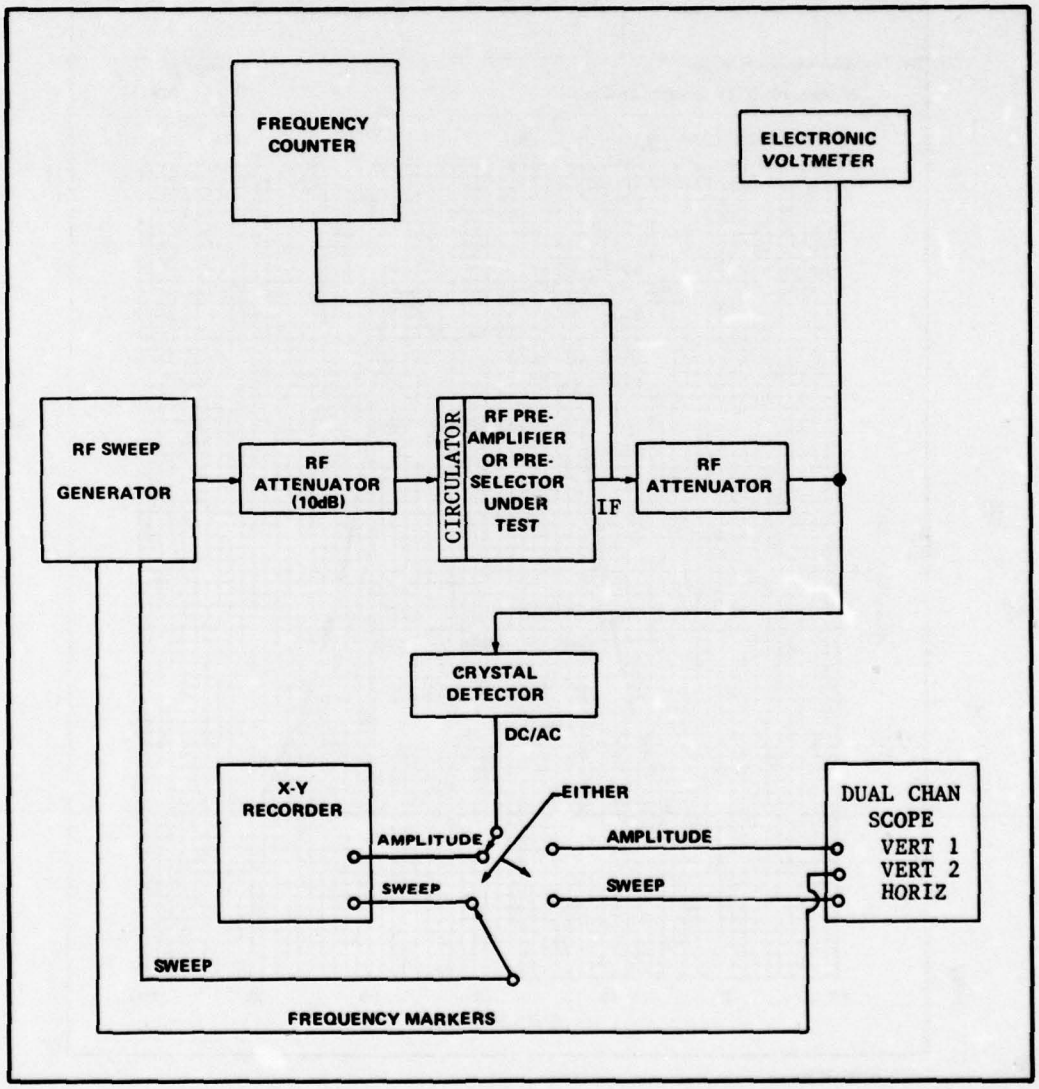


Figure 41-1. RF amplifier test setup.

GENERAL PURPOSE GRAPH PAPER

PAGE _____ OF _____ PAGES

DATA SHEET

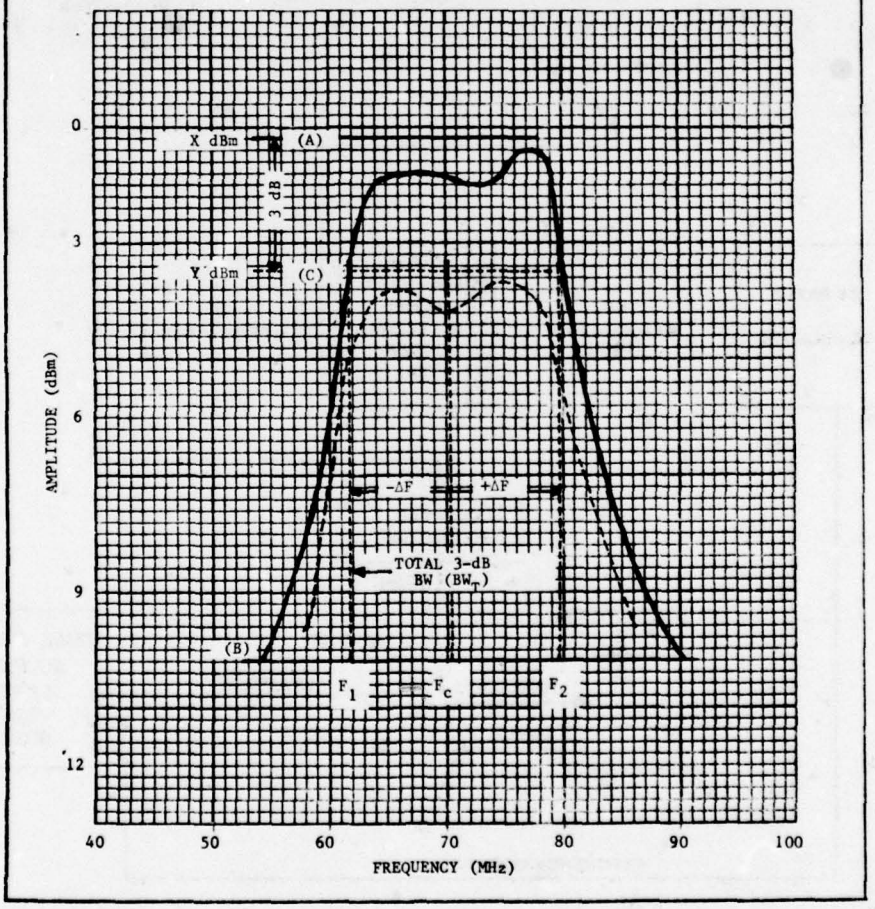
DATE (day, mo., year)

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE

TITLE OF PERFORMANCE PLOTTED: RF Amplifier Frequency Response

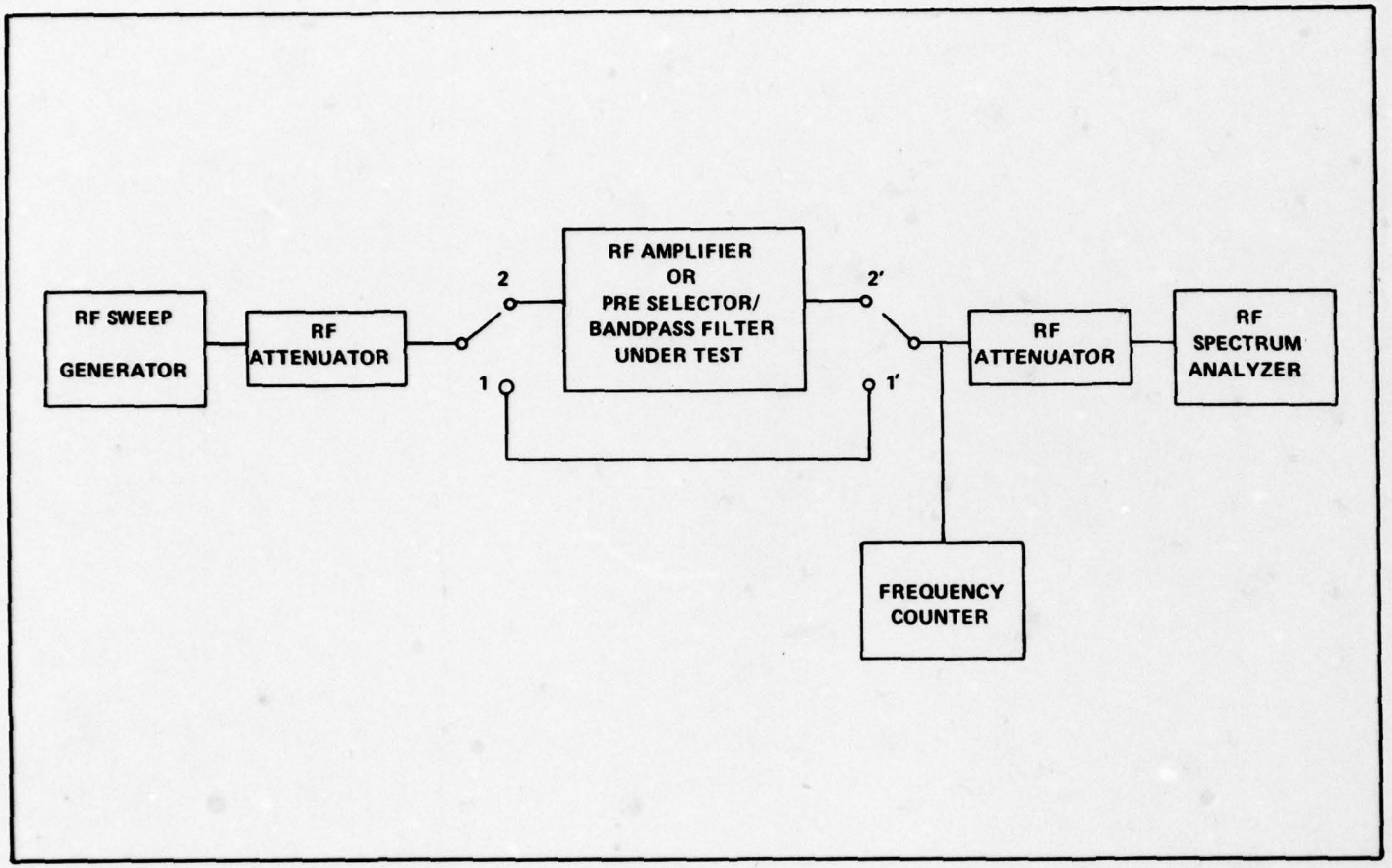
TEST NO.: DT-238

POWER GAIN 15 to 25 dB 3-dB BW 10 MHz



DD FORM 2094

Figure 41-2. Typical frequency response (RF/IF) curves.



CCP 702-11

Figure 41-3. RF amplifier power gain test setup.

CHAPTER 42

RECEIVER AUTOMATIC FREQUENCY CONTROL (DT-239)

42-1. GENERAL.

a. The purpose of this test is to determine the AFC tracking range and the accuracy of the receive IF signal relative to its normal or center frequency.

b. The AFC of the receiver must be capable of tracking minor variations in the transmitted RF carrier and maintaining a suitable frequency at the discriminator output of the receiver. As the incoming RF signal is mixed with the local oscillator output frequency, a voltage proportional to the change in frequency is fed back from the discriminator to the local oscillator as a correcting voltage. This correction voltage will tend to ensure that a 70-MHz signal appears at the IF over the tracking range of the AFC.

c. In the AN/FRC-( ), the transmitter and receiver frequency drift alarms are a function of the stabilized crystal controlled oscillators. The transmitter frequency is a function of the stability of the 140-MHz crystal oscillator in the MODEM plus the stability of the local oscillator in the up converter. The receiver local oscillator signal is supplied by a crystal-oscillator, phase-locked oscillator in the down converter.

d. This test may be performed on the AN/FRC-162 modified FM radio or the AN/FRC-( ).

e. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

42-2. SPECIFICATIONS.

a. No criteria exists for current models of the AN/FRC-162; however, earlier versions required that signals 7 MHz or more from the assigned frequency of a level of -75 dBm shall not cause the receiver to lock on an unwanted signal. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

42-3. TEST EQUIPMENT REQUIRED.

a. Power meter.

b. Thermistor/bolometer.

c. RF sweep generator.

d. RF counter.

e. Voltmeter.

f. Attenuators and connectors, as required.

42-4. TEST PROCEDURES.

a. Establish the test configuration as shown in figure 42-1 and allow approximately 30 minutes for warmup and stabilization.

b. Disconnect the RF receiver from the antenna at the RF interface point, if applicable. Set the generator to the assigned frequency of the receiver using the frequency counter. The generator output should not exceed -40 to -50 dBm input to the receiver.

c. Record the nominal IF signal frequency (IF_c) in MHz on figure 42-2 (DD Form 2103).

d. Connect the frequency counter to the IF signal output (J3 of the mixer amplifier or J4, 70-MHz test point of the AN/FRC-162, and the 70-MHz loop test point of the AN/FRC-( )). Measure and record the IF signal frequency. Calculate and record the AFC IF signal frequency accuracy from:

$$\% \text{ Accuracy} = \frac{((IF)_c - (IF)_{cm})}{(IF)_c} \times 100$$

e. Increase the generator frequency slowly, and monitor the IF signal frequency and the AFC (DC) voltage. Note that both the IF signal frequency and the AFC voltage will change as the generator frequency is increased, but tend to return to their original values. When the IF signal frequency and AFC voltage no longer return to their initial values, the limit of the tracking range has been reached. At this point, measure and record the RF generator frequency, $(RF)_u$; the IF signal frequency, $(IF)_u$; and the AFC voltage. If the AFC alarm activates before the AFC tracking limit is reached, record the frequency at which the alarm activated on figure 3-7 (DD Form 2091).

f. Repeat the above procedures, except slowly decrease the RF sweep generator frequency. Measure and record $(RF)_\ell$, $(IF)_\ell$, and the AFC voltage.

g. Calculate and record the AFC tracking range for the RF singal $(RF)_r$ as follows:

$$(RF)_r = (RF)_u - (RF)_\ell, \text{ MHz}$$

$$(IF)_r = (IF)_u - (IF)_\ell, \text{ MHz}$$

h. Reestablish the center frequency of the IF as measured with the frequency counter with the AFC off. Turn the AFC on, and if so equipped, observe the built-in AFC meter. The meter should return to zero providing the discriminator is properly adjusted and an IF of 70 MHz has been established. If the

meter does not return to zero, realine the receiver. If a built-in panel meter is not available or the calibration is questionable, perform the same procedure, except monitor the voltage at the AFC test point with an external meter.

i. Repeat the above procedure for other receivers to be tested.

42-5. DATA RECORDING AND ANALYSIS.

a. Review all test results to ensure completeness and that the receiver meets specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the receiver fails to meet specified requirements, notify the responsible activity of required corrective actions.

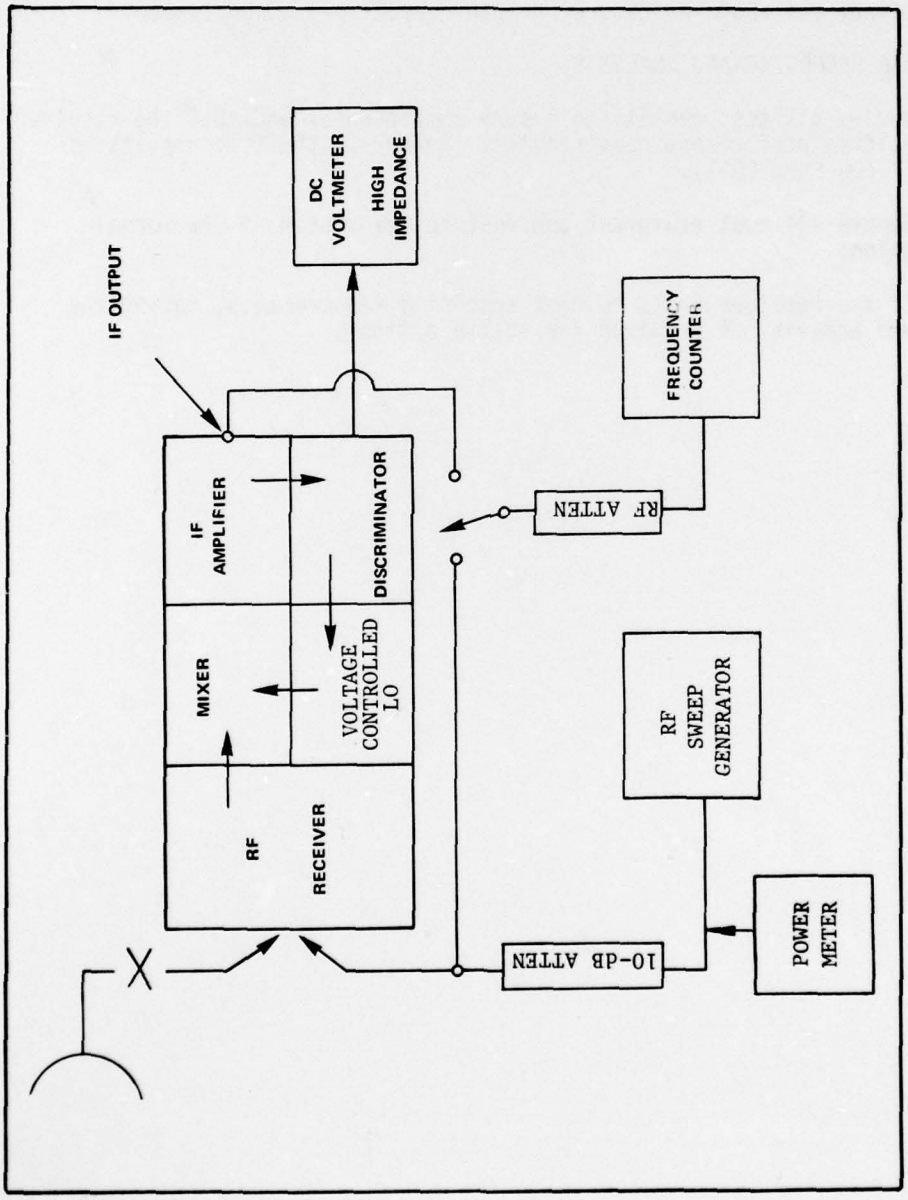


Figure 42-1. Receiver AFC test setup.

AUTOMATIC FREQUENCY CONTROL (AFC) CHARACTERISTICS

PAGE _____ OF _____ PAGES

DATE

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

RECEIVER

REC NO.	$(RF)_C$ ASSIGNED RF-SIG. FREQ., MHz	LIMITS OF RECEIVER INPUT SIGNAL FREQ. MHz		AFC RF-SIG. TRACKING RANGE, MHz	$(IF)_C$ NOMINAL IF-SIG. FREQ., MHz	LIMITS OF IF SIGNAL FREQ. CONTROL MHz		AFC IF-SIG. TRACKING RANGE, MHz	LIMITS OF AFC ERROR D.C. VOLTAGE MV.		$(IF)_{CM}$ IF-SIG. MS'D. CEN. FREQ., MHz	AFC IF-SIG. FREQUENCY ACCURACY %
		$(RF)_U$	$(RF)_L$			$(IF)_U$	$(IF)_L$		UPPER	LOWER		
1												
2												
3												
4												

TRANSMITTER

TXR NO.	AUTHORIZED TRANSMIT FREQUENCY F_a MHz	TRANSMITTER OUTPUT			AFC TRACKING RANGE $F_R = \lvert F_{MAX\text{-}2} - F_{MAX\text{-}1} \rvert$ MHz	AFC ACCURACY $= \frac{F_a - F_{MIN}}{F_a} \times 100$ %
		FREQUENCY AT DISCRIMINATOR MAXIMUM D.C. OUTPUT #1 FMAX-#1 MHz	FREQUENCY AT DISCRIMINATOR MAXIMUM D.C. OUTPUT #2 FMAX-#2 MHz	FREQUENCY AT DISCRIMINATOR MAXIMUM D.C. OUTPUT AND OSCILLATOR NORMAL TUNING POSITION FMIN MHz		
1						
2						
3						
4						

DD FORM 1 SEP 77 2103

Figure 42-2. Receiver AFC data sheet.

CHAPTER 43

TRANSMITTER AUTOMATIC FREQUENCY CONTROL (DT-240)

43-1. GENERAL.

a. The purpose of this test is to determine the transmitter AFC tracking capability and tracking range.

b. Before performing this test, the equipment technical specifications should be consulted and the AFC circuits properly alined. When an equipment technical manual provides a specification for the AFC tracking range, it is usually specified as plus and minus a specific deviation from the assigned carrier frequency.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

d. In the AN/FRC-162, the AFC function is accomplished by sampling the frequency of the 2-GHz transmit subcarrier and comparing the sample to a crystal-controlled reference frequency. Any difference detected during comparison is converted to a DC control voltage that corrects the 2-GHz oscillator frequency.

e. In the AN/FRC-( ), a crystal-controlled, phase-locked local oscillator provides the required operating stability of the transmitter. A 2-GHz cavity oscillator deviates from an integral multiple of the reference; a phase error and an error voltage is generated in the phase detector. A typical diagram of a phase-locked reference oscillator is shown in figure 43-1.

43-2. SPECIFICATIONS. The radio shall operate as specified in the standard engineering plan, contract specifications, or equipment technical manual.

43-3. TEST EQUIPMENT REQUIRED.

a. Voltmeter.

b. RF counter.

c. Adapters and connectors, as required.

43-4. TEST PROCEDURES.

a. Remove the modulation from the transmitter by disconnecting the baseband input (if applicable). Terminate the transmitter output into a dummy load to prevent radiation at unauthorized frequencies.

b. Connect the test equipment as shown in figure 43-2 and allow approximately 30 minutes for warmup and stabilization.

c. Connect the frequency counter through adequate attenuation to the RF test point at the RF interface. Connect the high impedance voltmeter to the discriminator or phase-lock loop test point.

d. Complete the top portion of figure 42-2 (DD Form 2103). Enter the authorized transmit frequency for each transmitter to be tested on the data sheet (F_a).

e. Disable the transmitter AFC or phase-lock loop circuit and mechanically detune the transmitter (2-GHz oscillator) until maximum discriminator or minimum phase-lock loop voltage output is noted on the voltmeter. Record the transmitter output frequency on the data sheet. Detune the transmitter oscillator in the opposite direction until maximum discriminator or minimum phase-lock loop voltage is again obtained. Record the transmitter output frequency on the data sheet.

f. Retune the transmitter oscillator to the authorized transmitter output frequency as recorded on the data sheet (F_a) and ensure that the discriminator shows minimum output voltage.

g. While performing the procedures described in subparagraphs e and f, above, record the frequency at which an AFC or phase-lock loop alarm occurs on figure 3-7 (DD Form 2091).

h. Reactivate the AFC or phase-lock loop after the oscillator has stabilized. Record the final frequency on the data sheet (F_{min}). At F_{min} and with the transmitter AFC on, the discriminator output should be at or near zero voltage as read on the external voltmeter or internal panel meter. If the built-in meter on the AN/FRC-162 is not within ±3 scale divisions, realine the AFC circuit.

i. Calculate and record on the data sheet the AFC or PLL tracking range (F_r) using the following formula:

$$F_r = F_{max-2} - F_{max-1}, \text{ MHz}$$

j. Calculate and record the AFC or phase-lock loop accuracy from:

$$\% \text{ Accuracy} = \frac{F_a - F_{min}}{F_a} \times 100$$

k. Repeat the above procedure for other transmitters to be tested.

43-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for completeness and compliance to specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the transmitter fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

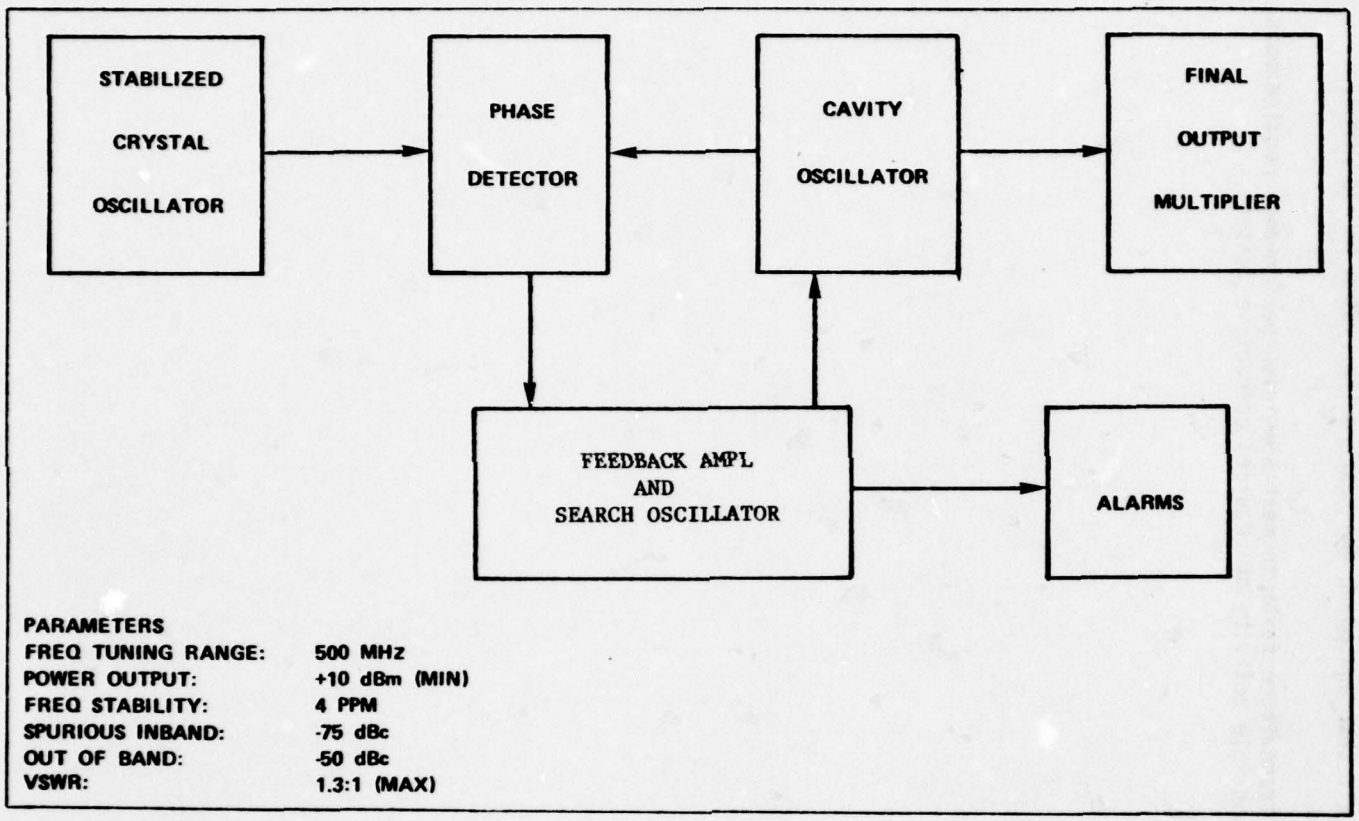


Figure 43-1. Typical phase-locked oscillator (AN/FRC-( )).

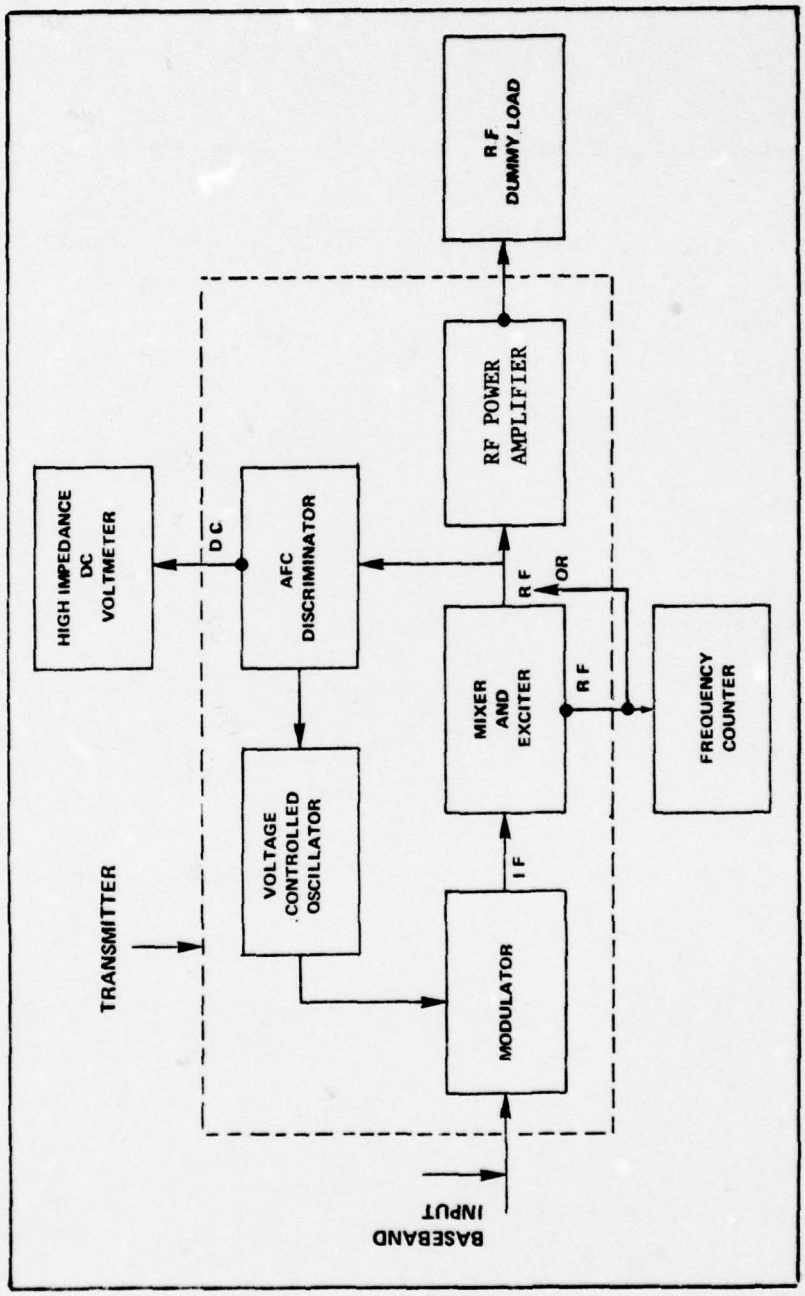


Figure 43-2. Transmitter AFC test setup.

CHAPTER 44

TRANSMITTER RF POWER GAIN AND BANDWIDTH (DT-241)

44-1. GENERAL.

a. The purpose of this test is to measure the gain and bandwidth of the RF amplifier including TWT and solid state amplifiers. Unless otherwise specified, the amplitude bandwidth is understood to be between the half-power frequencies.

b. Techniques for measuring the RF spectrum density which essentially reflects the final RF bandwidth of the transmitter are contained in DT-224.

c. The bandwidth of a device can be defined as the difference between the lower and upper limits of its frequency response. The limit in frequency response is the point where the gain of the device falls a preselected amount below the maximum gain. The preselected amount may be 1 or 3 dB. In most cases, it is referred to as the 3-dB point.

d. For communications purposes, the bandwidth of the radio equipment must be just wide enough to pass the carrier and the intelligence being carried in the sidebands. If it does not, then a portion of the original intelligence may be lost. If the bandwidth is unnecessarily wide, then unwanted noise and extraneous signals could be introduced into the system.

e. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

44-2. SPECIFICATIONS.

a. The following criteria applies to transmitter operation: (MIL-STD-188-313).

(1) *Necessary bandwidth.* The necessary bandwidth (equipment design purposes) for wideband frequency modulated systems shall be determined from the formula 2 ($\Delta F_C + F_m$) where ΔF_C is the peak carrier deviation and F_m is the highest modulating frequency.

(2) *Measurement Bandwidth.* The measurement bandwidth is determined by the formula 2.8 ($\Delta F_C + F_m$) where ΔF_C is the peak carrier deviation and F_m is the highest message band modulating frequency in kHz. This measurement bandwidth also defines the radio equipment RF and IF bandpass bandwidth and 0.1-dB bandwidth.

(3) *Linearity bandwidth.* The linear bandwidth is determined by the formula 1.4 ($\Delta F_C + F_m$) where ΔF_C is the peak deviation and F_m is the highest modulating frequency.

b. The occupied bandwidth (AN/FRC-162), measured at the output of the transmitter, is the frequency bandwidth occupied by 99 percent of the radiated power and shall be less than 14 MHz. The radiation outside the range of 15 MHz each side of the RF center frequency shall be less than 50 dBm. (SCCC-73017)

NOTES: 1. The above is more applicable to DT-224, rather than this test; however, it does provide the required bandwidth under full modulating conditions.

2. Refer to DT-224 for emission limitations and specifications for the AN/FRC-( ).

c. The radio shall operate as specified in the standard engineering plan, contract specifications, or the equipment technical manual.

44-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. RF sweep generator.

c. X-Y recorder.

d. Crystal detector.

e. Voltmeter.

f. Power meter with bolometer.

g. Oscilloscope.

h. Attenuators, connectors, cables, and adapters, as required.

i. Directional coupler, as required.

44-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 44-1, with the sweep on the generator turned off and the output power off. Allow approximately 30 minutes for warmup and stabilization. Repeat these procedures for other radios to be tested.

b. For the AN/FRC-162, proceed as follows:

(1) Adjust the sweep generator output power in the CW mode to provide a sufficient drive level into the TWT amplifier. Connect the generator output to J108 (quick disconnect flange). The insertion level should be a minimum of 4 dBm with 8 dBm nominal.

(2) Ensure tht the TWT amplifier is terminated into its characteristics impedence either through a dummy load or antenna.

(3) If the generator does not have sufficient output to drive the RF amplifier, insert the generator output at a preceding low power point. In this case, insert the signal at the coaxial coupler before the load isolator or at one of the frequency multiplier stages. This will not provide a true measure of the RF bandwidth and gain of the TWT; however, it will provide the response of the various transmitter sections to include the RF amplifier.

(4) If desired, use a power meter instead of the electronic voltmeter for establishing a safe power level to the crystal mixer as shown in figure 44-1.

(5) Set the power output of the generator to correspond to the level as specified for the test point being used. Set the frequency of the generator to the center frequency (F_C). The nominal RF bandwidth for the AN/FRC-162 is 25 MHz for 12.6 mb/s of data. Use a range of values of the frequency markers from the sweep generator to establish a frequency scale on the oscilloscope. Adjust the oscilloscope gain and position-of-pattern controls so that the display occupies at least two-thirds of the screen, and the baseline (B) and center frequency (F_C) fall at established reference lines as shown in figure 41-2.

(6) To calibrate the frequency scale on the X-Y recorder, turn the sweep on the generator to manual sweep. Manually vary the frequency of the generator across the specified IF/RF spectrum and establish the frequency calibration on the X-Y recorder using figure 3-4 (DD Form 2094). Set the sweep of the generator so that the tracking capability of the X-Y recorder is not exceeded. Mark the center frequency (F_C), the amplitude (A), the baseline (B), and the 3-dB bandwidth (C).

(7) Attenuate the input signal to the device by 3 dB. Readjust the vertical positioning of the oscilloscope trace or the X-Y recorder, if necessary, so that the baseline (B) falls at the same position as established above. Mark the positioning level (C) at the point where the dotted curve crosses the center frequency (F_C).

(8) Remove the 3-dB attenuation and reposition the baseline (B) to the original reference. In the X-Y recording, two curves will be displayed on the data sheet, with an amplitude difference of 3 dB from which values for the 3-dB bandwidth (BW_T) ($F_C + \Delta F$ and $- \Delta F$) can be determined.

(9) Record the center frequency (F_C), the total 3-dB bandwidth (BW_T), and the plus and minus 3-dB bandwidths from (F_C), ($+ \Delta F$ and $- \Delta F$) on the data sheet. If additional space is required for comments, use figure 3-7 (DD Form 2091).

(10) When the frequency scale has been established on the screen as outlined in subparagraph (5), above, use the oscilloscope, if desired, to photograph the curve. Mount the photographs on figure 5-2 (DD Form 2093). If the frequency scale has not been established, tune the frequency marker across the spectrum of interest, noting and marking the frequencies at which the curve crosses the 3-dB reference line (C). Photograph the curve, making sure that

all important levels and frequencies are recorded. Mount the photographs on the data sheet, recording the center frequency (F_C), the total 3-dB bandwidth (BW_T), and the plus and minus 3-dB bandwidths from the center frequency.

(11) To measure the 3-dB bandwidth of the RF amplifier and interconnecting waveguide and adapters between the amplifier and RF interface point, connect the equipment as shown in figure 44-1. Connect the oscilloscope directly at the RF interface flange.

c. For the AN/FRC-( ), proceed as follows:

(1) Perform the procedures outlined in paragraphs 44-4 a and b with the minor changes as described in the following subparagraphs.

(2) Measure the bandwidth and gain of the RF chain from the IF amplifier to the RF interface, either in tandem or as individual subsections at any accessible test point within the radio. Typical performance characteristics of the radio RF/IF section are shown in figure 44-2. Typical response and gain curves of the transmit bandpass and diplex RF filters are shown in figure 44-3. Typical block diagrams of space and frequency diversity are shown in figure 44-4.

(3) Disconnect the digital multiplexer and the linear modulator input to the transmit buffer amplifier (IF amplifier) when performing the bandpass test.

(4) Since the radio is designed to accept a number of bit rates, exercise caution to ensure that the radio is being tested at the designed bandwidth.

(5) If additional space is required for recording data, use figure 3-7 (DD Form 2091).

44-5. DATA RECORDING AND ANALYSIS.

a. Review the test results for compliance with the specified requirements and equipment technical literature. Ensure that all data elements are complete. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system fails to meet specified requirements, notify the responsible activity of required corrective actions.

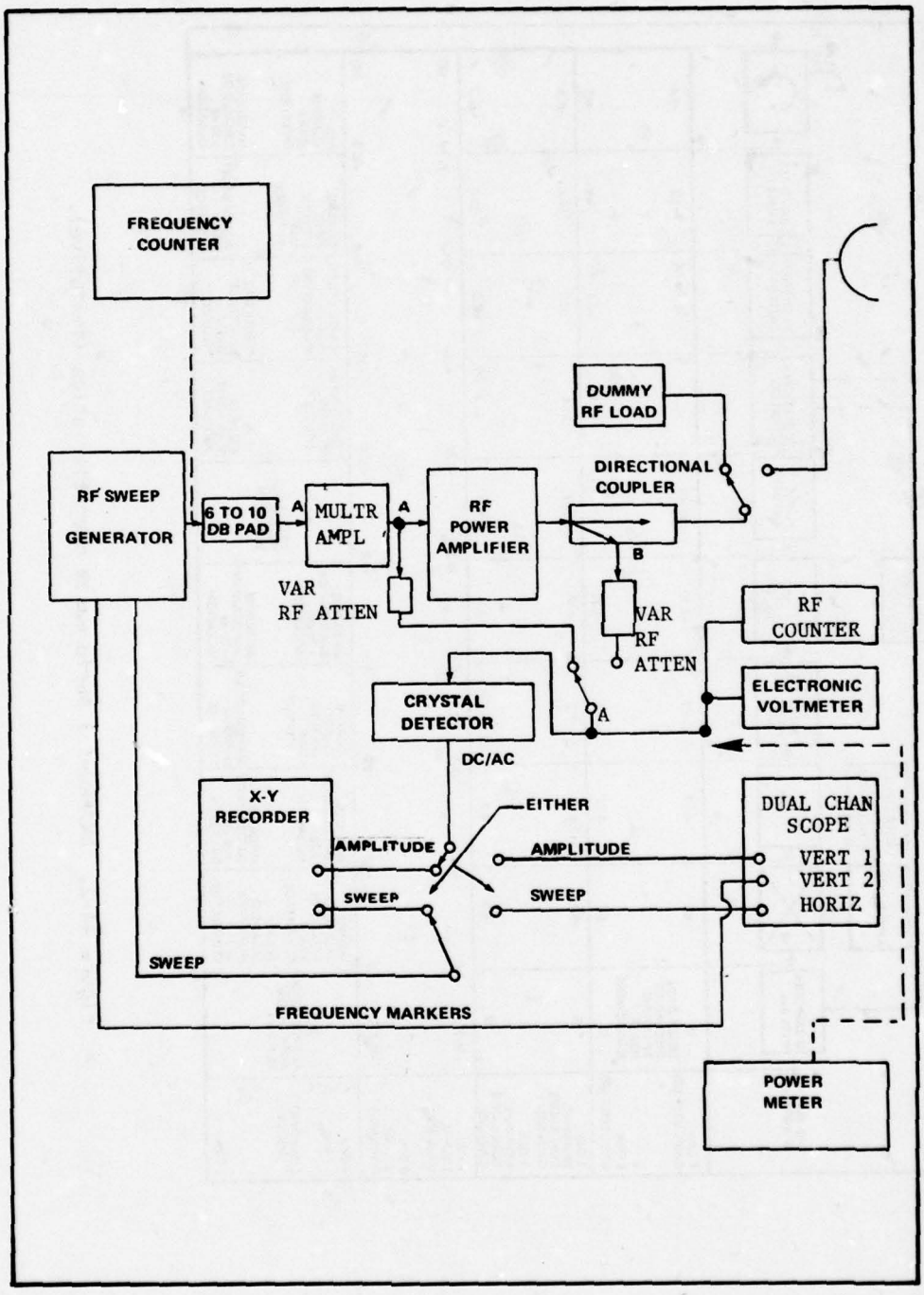


Figure 44-1. Transmitter power gain and bandwidth test setup.

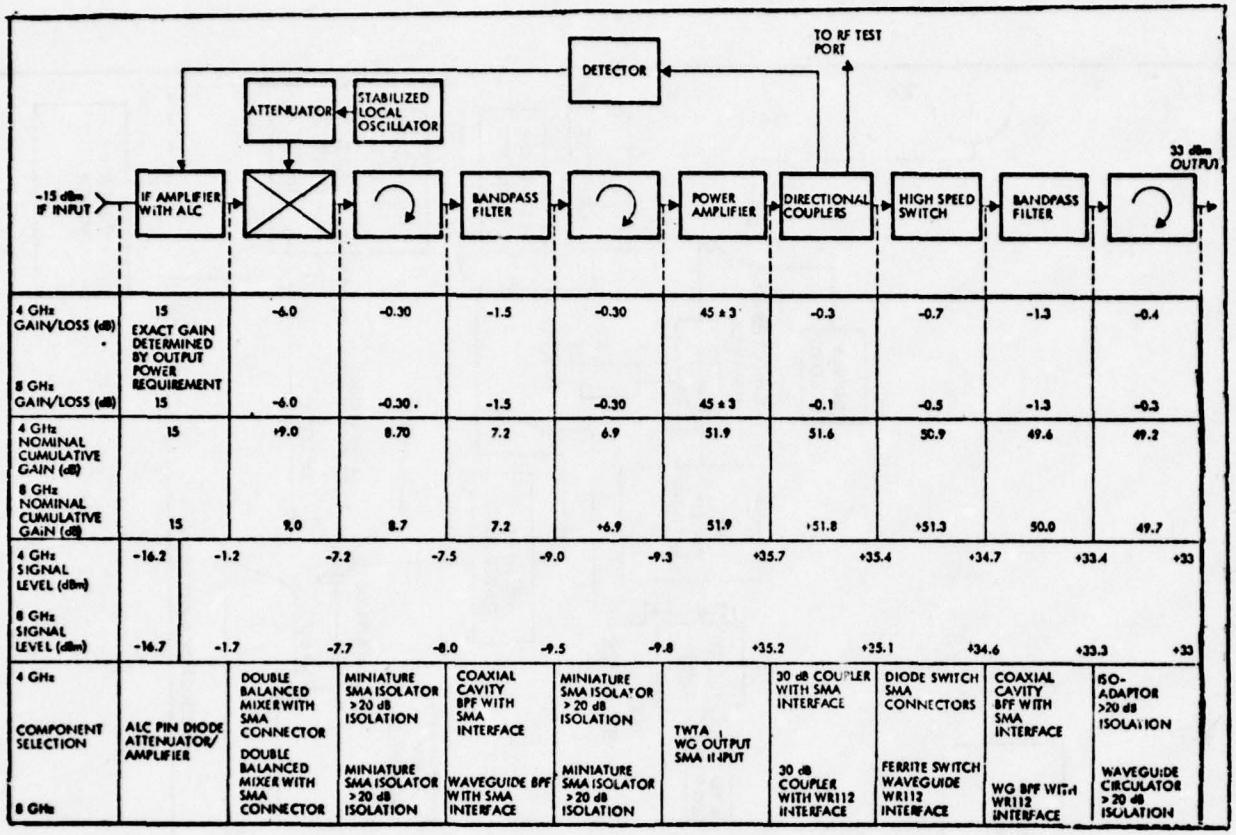


Figure 44-2. AN/FRC-( ) performance characteristics (tentative).

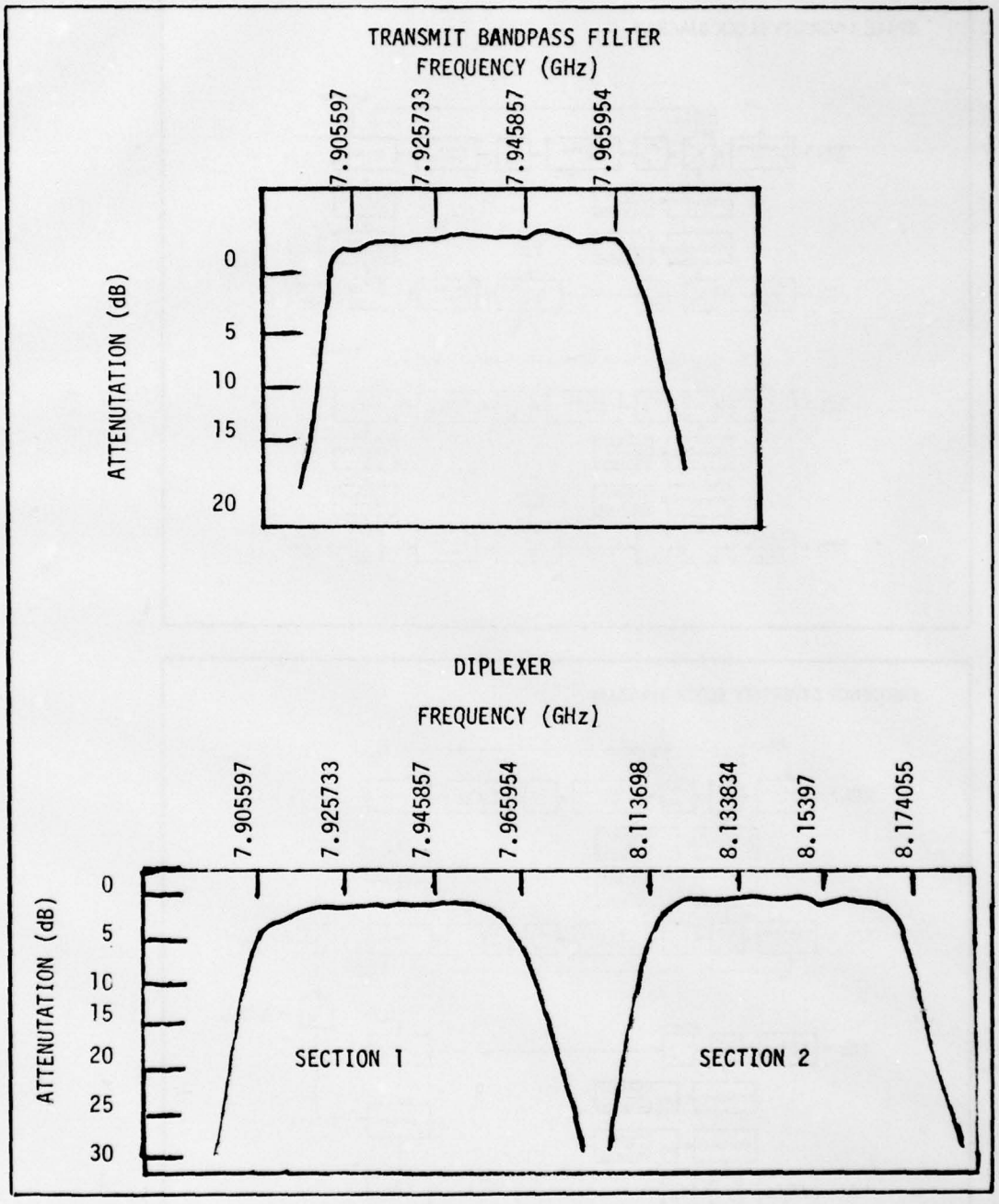
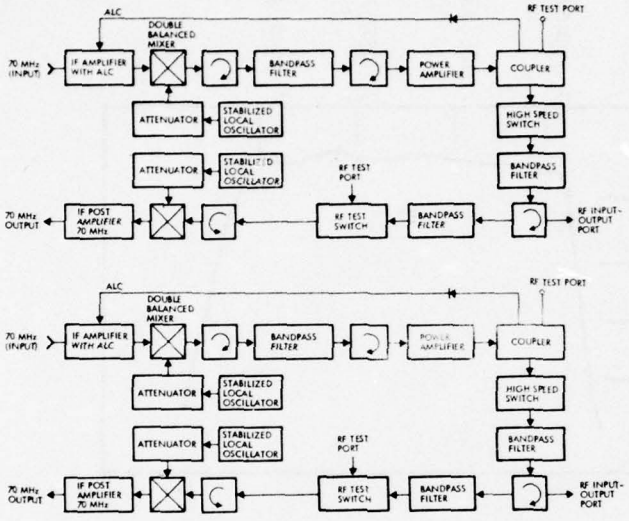


Figure 44-3. Typical response of RF filters.

SPACE DIVERSITY BLOCK DIAGRAM



FREQUENCY DIVERSITY BLOCK DIAGRAM

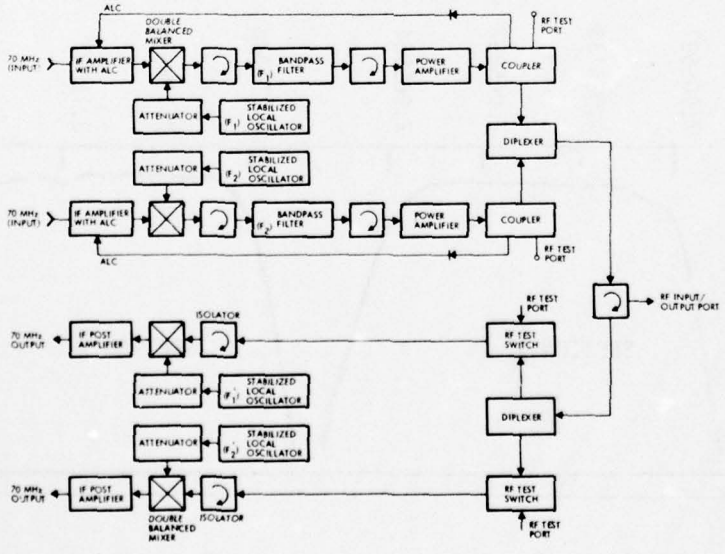


Figure 44-4. Typical block diagrams of the AN/FRC-( ).

CHAPTER 45

RECEIVER INTERMEDIATE FREQUENCY BANDWIDTH DISCRIMINATOR (DT-242)

45-1. GENERAL.

a. The purpose of this test is to measure the receiver IF amplifier frequency response (bandwidth) gain, and discriminator response and linearity.

b. The gain of the IF amplifier may not be measured directly because of the limiter circuitry; however, a disparity in the gain should be reflected in the AGC voltage. If required, the limiter circuit may be deactivated by switch S101. The gain would then be measured at the input to the filter equalizer of the AN/FRC-162.

c. The two commonly accepted methods of measuring the IF response and bandwidth are with a spectrum analyzer or an X-Y recorder. These methods and techniques are described in paragraph 45-4, below.

d. The function of the IF amplifier is to raise the level of the IF signal to a point where it will drive the demodulator. Some of the important parameters of the IF are the frequency, gain, bandwidth, and harmonic suppression. For optimum reception, the amplifier must have sufficient bandwidth to accommodate the carrier and the intelligence carried in the sidebands.

e. The discriminator (may be different in an AN/FRC-( )) converts the incoming signal frequency variations to a wave that represents the modulating intelligence after the signal has gone through some amplitude limiting device. Two sources of distortion are: (1) when the discriminator is nonlinear over the required bandwidth and (2) when the incoming IF signal does not coincide with the center frequency of the discriminator.

f. A plot of a typical discriminator curve and the IF bandpass of an FM radio is shown in figure 45-1. The discriminator curve also shows the degree of linearity over the required bandwidth as opposed to the ideal linearity of the discriminator.

g. To facilitate analyzing the bandpass and discriminator curves, the data should be plotted on the same data sheet. If an X-Y recorder is not used for plotting of the curves, photographing an oscilloscope or spectrum analyzer display of the IF bandwidth and manually plotting the discriminator will yield satisfactory test results. If a microwave analyzer is used, it will be possible to observe and photographically record both the IF and discriminator curves.

h. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

45-2. SPECIFICATIONS.

a. The following criteria applies to the receiver: (MIL-STD-188-313)

(1) *Linearity bandwidth.* The linear bandwidth shall be determined by the formula 1.4 ($\Delta F_c + F_m$) where ΔF_c is the peak deviation and F_m is the highest modulating frequency.

(2) *Necessary bandwidth.* The necessary bandwidth shall be determined from the formula 2 ($\Delta F_c + F_m$).

(3) *Measurement bandwidth.* The measurement bandwidth shall be determined from the formula 2.8 ($\Delta F_c + F_m$).

(4) *Dynamic range.* The receiver demodulator sensitivity (μv per MHz) shall remain constant ±0.5 dB for RF input signals in the range of 10 to 50 dB above the receiver threshold.

b. The following criteria applies to the AN/FRC-162: (SCCC-73017)

(1) The output of the demodulator, portrayed as a function of the peak deviation of the input signal, shall be linear within 1 percent over the IF between 65 and 75 MHz and 10 percent between 62 and 78 MHz.

(2) The IF bandwidth for 12.6 mb/s of data loading shall be 25 MHz.

NOTE: Current specifications do not require different IF bandwidths; however, they may be encountered during field testing.

c. The radio shall operate as specified in the standard engineering plan, contract specifications, or equipment technical manuals.

45-3. TEST EQUIPMENT REQUIRED.

a. IF sweep generator.

b. Frequency counter.

c. RF voltmeter.

d. X-Y recorder.

e. DC voltmeter.

f. Oscilloscope.

g. Spectrum analyzer.

h. Power meter (optional).

i. Crystal detector.

j. Spectrum analyzer (HP 141T).

k. Tracking generator (alternate).

l. Attenuators, adapters, cables, etc., as required.

45-4. TEST PROCEDURES.

a. Radio Set AN/FRC-162.

(1) Response.

(a) Connect the test equipment as shown in figure 45-2 and allow approximately 30 minutes for warmup and stabilization.

(b) Connect the output of the generator to the IF input at J2 of the IF module. Connect the crystal detector and attenuator to the IF before limiting at terminals E105 and E104 (S102) if gain measurements are being made. If the measurement being performed is bandpass response only, connect the detector to the output of the AGC amplifier at TP-3.

(c) Turn the generator to 70 MHz with the sweep and output level turned off. If the detector is used as shown in figure 45-2, adjust the attenuators so that the spectrum analyzer and the crystal detector will not be overloaded by the IF amplifier signal.

(d) Adjust the sweep range of the generator to cover the IF bandpass of the receiver under test to include at least the 3-dB points. Adjust the output level of the generator to a convenient level between -7 and -67 dBm, and establish a quick display of the IF amplifier output. If the results are within specifications, record the response on figure 45-3 (DCA Form (Test) T39-2).

(e) To calibrate the frequency scale of the X-Y recorder, turn the sweep on the generator to manual. Manually vary the frequency of the generator in steps across the IF spectrum, as measured with the frequency counter. Establish the frequency calibration of the X-Y recorder.

(f) Calibrate the Y-axis of the recorder, in dBm or voltage, by varying the output attenuator and measuring the IF signal output power at the crystal detector or spectrum analyzer. The calibration range should be at least 50 dB.

NOTE: If the display is linear-to-voltage, the zero voltage and peak voltage points should be displayed on the graph so that the corresponding power levels can be determined in terms of dB.

(g) If an oscilloscope, spectrum analyzer, or X-Y recorder is not available, obtain the IF bandwidth response characteristics in terms of the IF signal output power versus specific IF signal frequencies by manually sweeping the IF spectrum with the IF signal generator. Sufficient point-by-point data should be taken to obtain a smooth curve similar to that shown in figure 45-1. Record the manual data on figure 45-4 (DD Form 2125) and use the data to plot a curve on figure 3-4 (DD Form 2094).

(2) IF amplifier gain.

(a) Connect the equipment as shown in figure 45-5, using the 1-1 connection for calibration.

(b) Turn the generator to CW and set the output frequency to 70 MHz with the frequency counter. Adjust the generator output power to a convenient level between -7 and -67 dBm. Ensure that saturation of the IF amplifier does not occur.

(c) Adjust the spectrum analyzer to display the signal at a convenient amplitude. For accuracy, the amplitude should be set to the peak of a known point on the display graticule by marking the position of the peak on the face of the analyzer or oscilloscope.

(d) Note the output setting of the output attenuator of the generator.

(e) Switch the connection to the 2-2 position (fig. 45-5) and connect the generator input to test point J2. Connect the spectrum analyzer to TP-1 (E105 and E104 at S102). If the analyzer is not in the 75-ohm position, use a 75-ohm termination ahead of the analyzer input.

(f) Vary the output attenuator setting until the amplitude of the signal displayed on the spectrum analyzer equals the level established in subparagraph (c) above.

NOTE: The power gain (in dB) is the difference between the attenuator settings noted in subparagraphs (c) and (f), above. The nominal IF power gain should be 12 dB.

(g) Record the test results on figure 45-3 (DCA Form (Test) T39-2). If additional space is required, use figure 3-7 (DD Form 2091).

NOTE: An RF power meter calibrated for 75 ohms may be substituted for the spectrum analyzer.

(h) To determine if the IF amplifier is flat and provides the required gain over the input design level, turn the generator sweep on and proceed with subparagraphs (i) and (j), below.

(i) Set the generator sweep to cover the IF bandpass of the receiver. Connect the spectrum analyzer to TP-1 (E105 and E104 at S102). Calibrate the analyzer to display a signal from -7 to -67 dBm by using the IF sweep generator and attenuators. Establish a reference on the anlayzer with an equivalent -7 dBm IF input, considering the gain of the amplifier.

(j) Starting with a -7 dBm IF input signal, reduce the input level in 10-dB steps while observing the sweep signal output of the IF on the spectrum analyzer. Continue reducing the IF input level until the -67 dBm point is reached. The response should be a flat ±1 percent over the input range and the gain should remain at 12 dB over the entire input level. Record the results on figure 45-3 (DCA Form (Test) T39-2). If additional space is required, use figure 3-7 (DD Form 2091).

(3) *Discriminator characteristics.*

(a) Without disturbing the calibration established in paragraph 45-4a(1), above, return the IF sweep generator to the IF center frequency. Connect the Y-axis of the recorder to the meter leads on the meter control panel. Disconnect the discriminator circuits from the meter by turning the meter switch to the receive position.

(b) Connect the voltmeter output to the Y-axis of the recorder and recalibrate the Y-axis of the recorder as necessary for a display similar to that shown in figure 45-1. Record the discriminator curve on the same data sheet as the IF bandpass recorded in paragraph 45-4a, above.

NOTE: The above will determine the discriminator characteristics from the IF amplifier input through the various IF stages.

(c) If discriminator linearity is to be determined separately, proceed with subparagraphs (d) through (g), below.

(d) Connect the IF sweep generator to the 70-MHz out test point J2, and set the generator to CW with an output level of -35 dBm as measured with the RF voltmeter shown in figure 45-6. The generator output frequency should be 70 MHz.

(e) Calibrate the X-Y recorder as outlined in paragraph 45-4a(1), above, to cover a frequency of ±8 MHz from the center frequency (62 to 78 MHz).

NOTE: An oscilloscope or analyzer may be used, if desired.

(f) Once calibration of the recorder or oscilloscope has been accomplished, turn on the sweep generator and record the discriminator linearity on figure 3-4 (DD From 2094).

(g) If the linearity is not within specified requirements (1 percent between 65 and 75 MHz and 10 percent between 62 and 78 MHz), adjust the linearity tilt, linearity bow, and discriminator zero as specified in the equipment manual.

(h) An alternate test setup using a spectrum analyzer and tracking generator is shown in figure 45-7.

b. Radio Set AN/FRC-( ) (Digital). The same basic procedures as outlined in paragraph 45-4a(1), above, will be performed on the AN/FRC-( ) with minor changes as follows:

(1) Connect the sweep generator at the IF amplifier 70-MHz loop at a convenient level between -17.9 and -67.9 dBm. The nominal level used will depend on the RF band for which the radio was designed. Since a bandpass filter is connected to the test point preceding the IF amplifier, the bandwidth, gain, and response may be affected by these components.

(2) Connect the RF voltmeter or spectrum analyzer to the output of the IF amplifier as shown in figure 45-2.

(3) If desired, perform response and gain tests on the IF amplifier following the procedures outlined in paragraph 45-4a(1), above. Performance characteristics for the IF amplifier of the AN/FRC-( ) are not yet available nor have specific test points been designated. Typical performance of the stages preceding the IF amplifier is shown in figure 45-8.

(4) Repeat the above procedures for other receivers to be tested. Complete the data sheets as outlined in paragraph 45-4a, above.

NOTE: The IF bandwidth of the IF amplifier in the AN/FRC-( ) without filtering is 45 MHz.

45-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for completeness, accuracy, and compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the receiver fails to meet specified requirements, notify the responsible activity of required corrective actions.

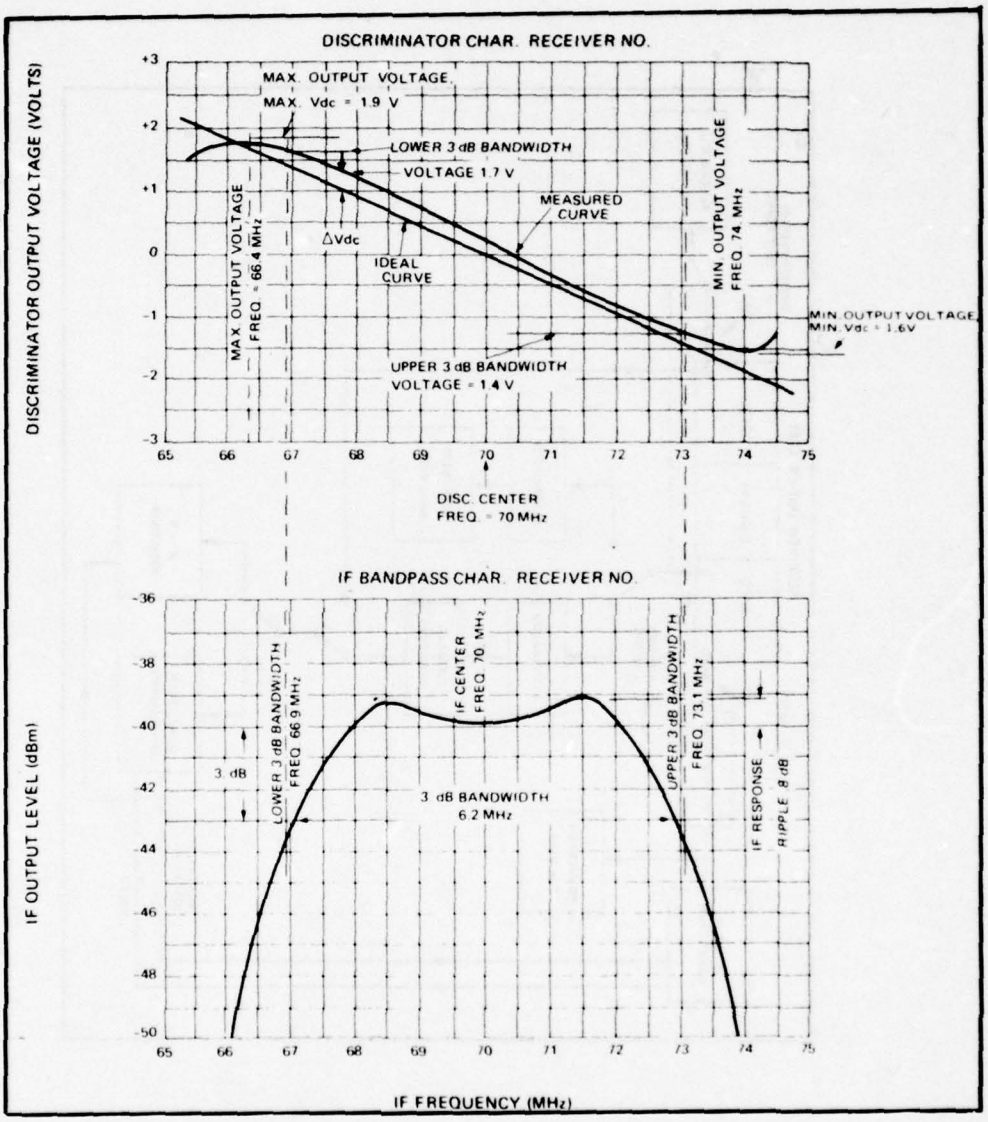


Figure 45-1. Typical receiver discriminator and bandpass curves.

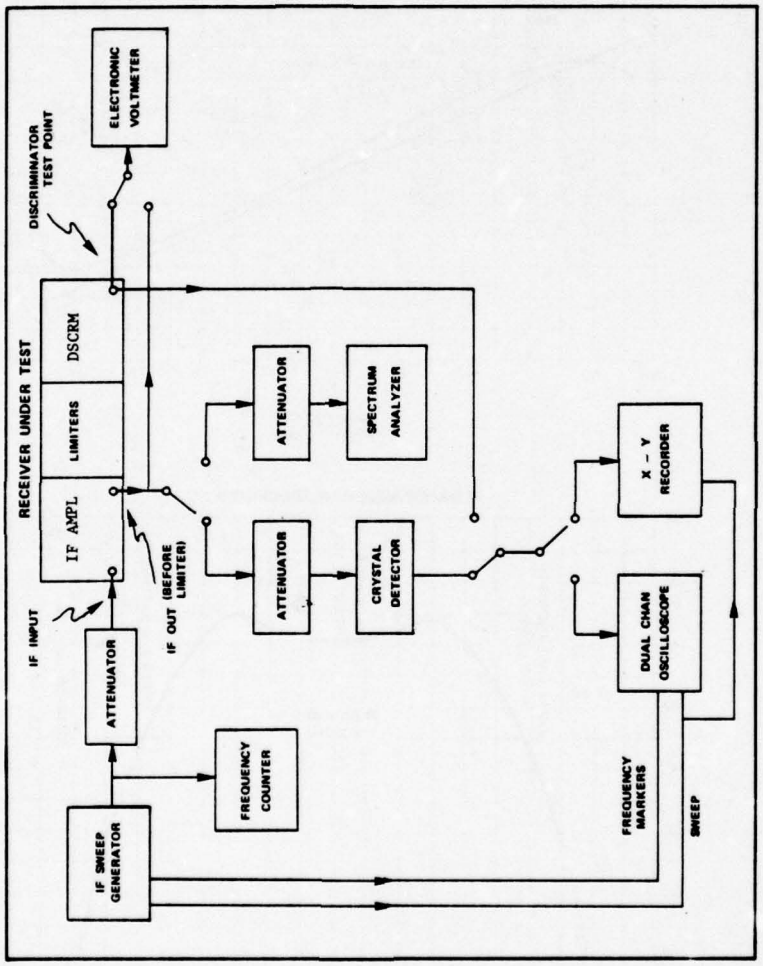


Figure 45-2. IF bandwidth response test setup.

RF RECEIVER BANDPASS AND DISCRIMINATOR CHARACTERISTICS SUMMARY SHEET

PAGE OF PAGES

DATA SHEET T39-2

DATE (day, mo., year)

DCS LINK NO	NO. OF VOICE CHANNELS		IF CENTER FREQ	STATION UNDER TEST	TEST ENGR SIGNATURE
	DESIGN	USED	MHz		

EQUIPMENT	APPARENT IF CENTER FREQUENCY (MHz)	IF 3 dB BANDWIDTH (MHz)	IF RESPONSE RIPPLE (dB)	IF 60 dB BANDWIDTH (+MHz –MHz)	DETECTOR CENTER FREQUENCY (MHz)	MAX. % DISC. LINEARITY UPPER IF SIDE	MAX. % DISC. LINEARITY LOWER IF SIDE
RECEIVER 1							
RECEIVER 2							
RECEIVER 3							
RECEIVER 4							
MOST APPLICABLE DCA STANDARD	70					0.0	0.0
STANDARD MET	☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO		☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO
TECH ORDER SPECIFICATION							
WITHIN LIMITS	☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO		☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO

COMMENTS:

DCA FORM (TEST) MAR 73 T39-2

EXPIRES SEPTEMBER 1973

Figure 45-3. Receiver IF bandwidth data sheet.

RECEIVER IF AMPLIFIER AND DISCRIMINATOR RESPONSE DATA (MANUAL PLOT)					PAGE _____ OF _____ PAGES DATE			
DCS LINK NO.	STATION UNDER TEST		DISTANT STATION		ENGR. INIT.		TECHN. INIT.	
	RECEIVER 1		RECEIVER 2		RECEIVER 3		RECEIVER 4	
IF FREQUENCY (MH_z)	IF OUTPUT LEVEL (dBm)	DISC. OUT (VOLTS)	IF OUTPUT LEVEL (dBm)	DISC. OUT (VOLTS)	IF OUTPUT LEVEL (dBm)	DISC. OUT (VOLTS)	IF OUTPUT LEVEL (dBm)	DISC. OUT (VOLTS)

DD FORM 1 SEP 77 2125

Figure 45-4. Receiver IF performance data sheet.

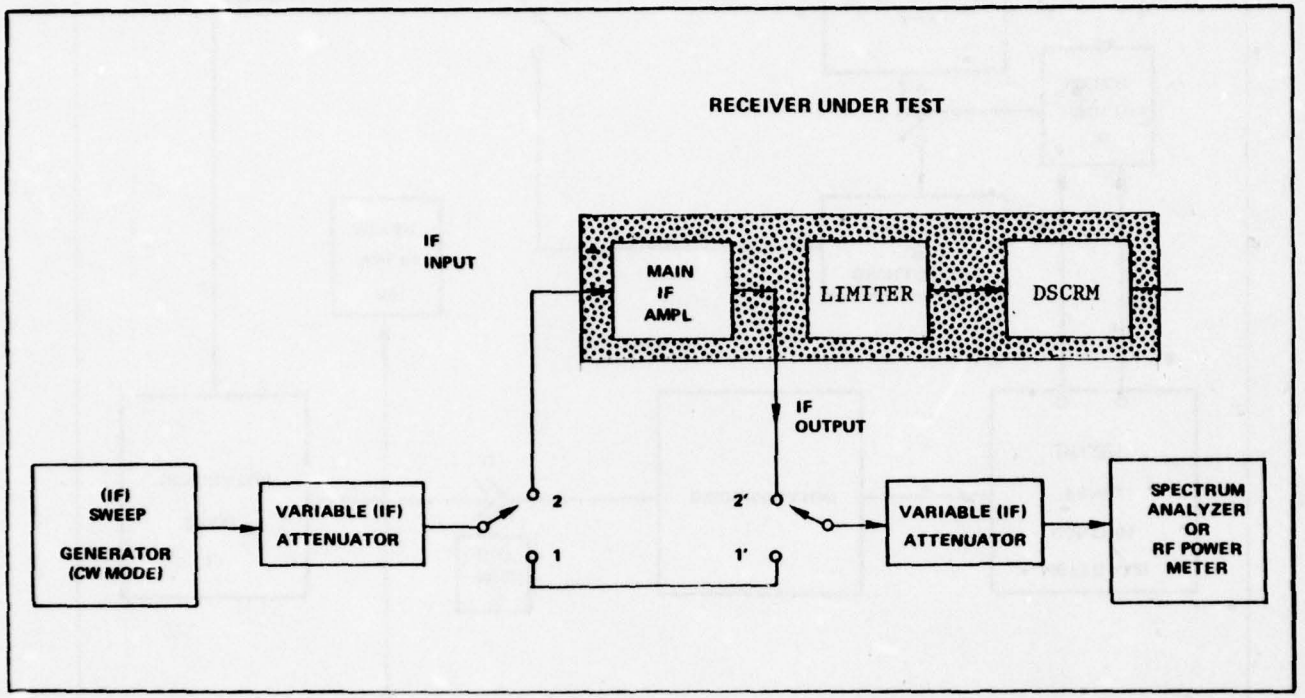


Figure 45-5. Receiver IF amplifier gain test setup.

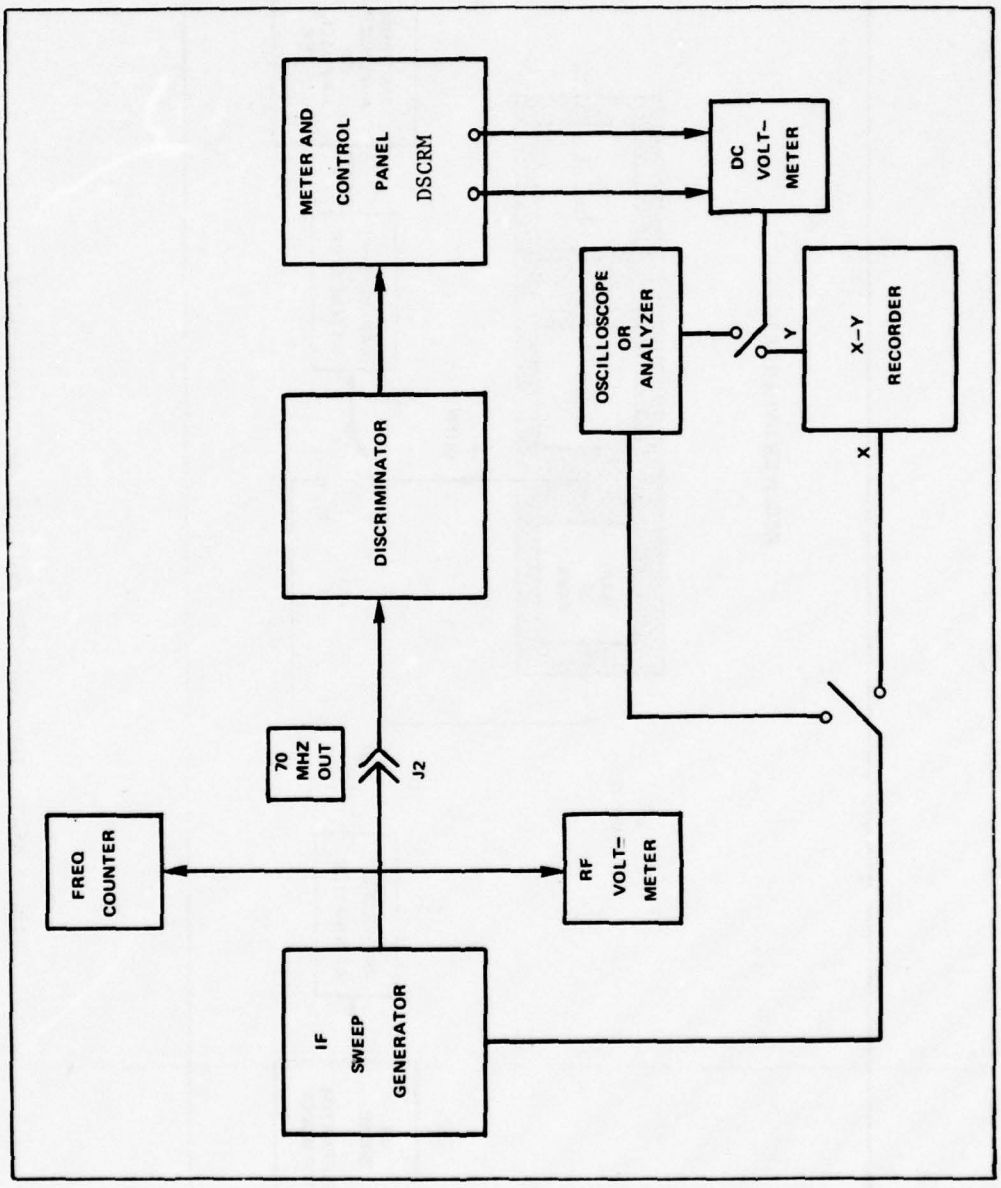


Figure 45-6. Receiver discriminator test setup.

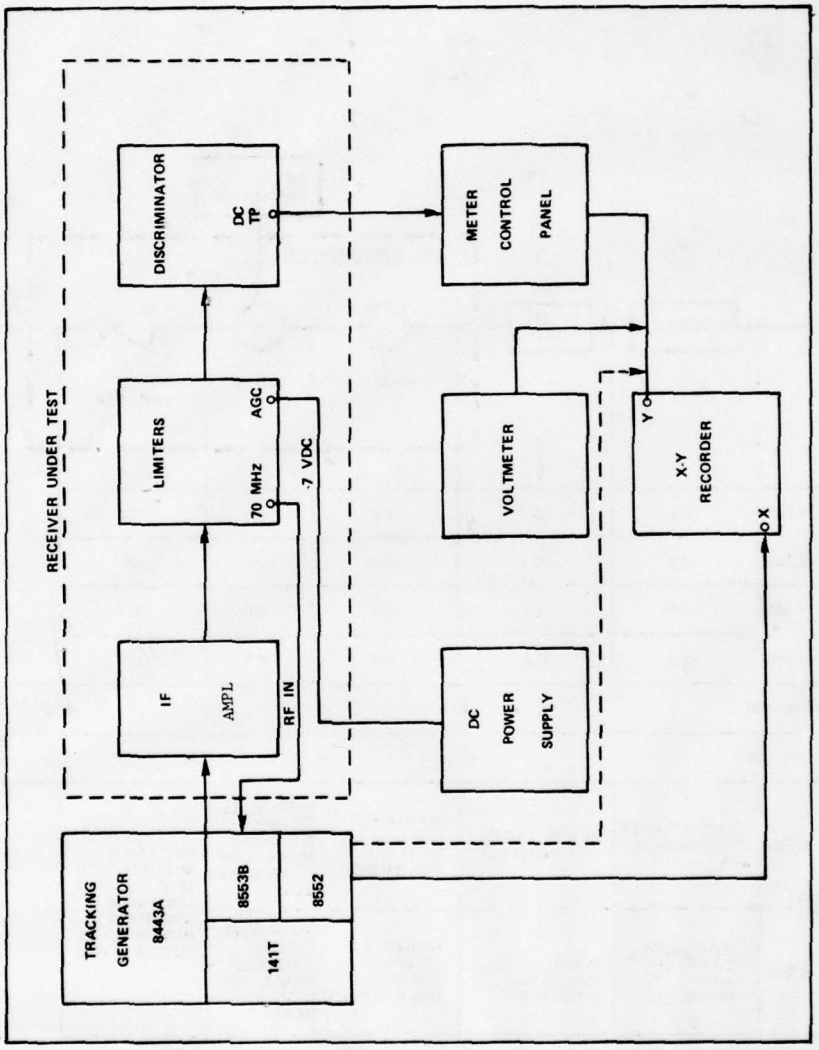


Figure 45-7. Receiver discriminator alternate test setup.

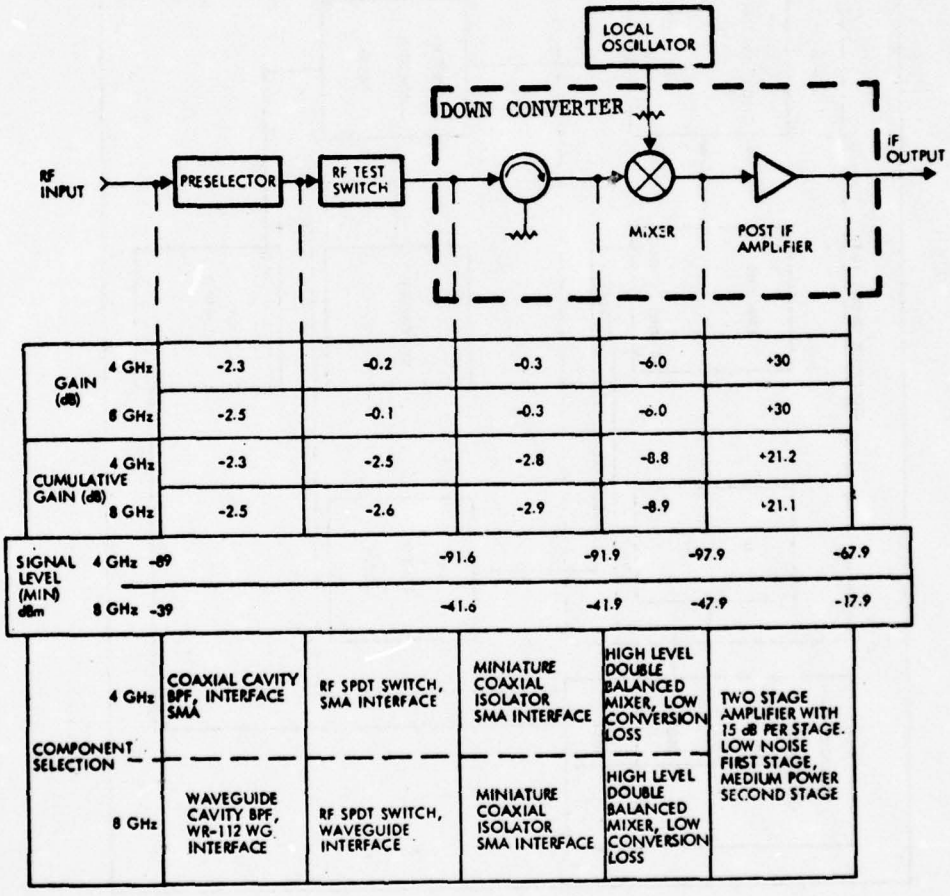


Figure 45-8. Typical performance characteristics of the AN/FRC-( ).

CHAPTER 46

RECEIVER PHASING
(DT-243)

46-1. GENERAL.

a. The purpose of this test is to measure the relationship between the baseband output signals of the receivers in a diversity system.

b. The phase differences observed provide an indication of the amount of distortion when the baseband signals are switched. The test uses the eye patterns of the traffic signals appearing at the baseband output or at the output of the demodulators for the AN/FRC-( ).

c. The test may be performed while the radio is in an RF loop and modulated with a pattern generator at the appropriate data rate. If configured on a link, existing traffic signals may be used.

d. In the AN/FRC-( ), the familiar eye pattern is not used to directly measure the signal quality. The processing, in effect, samples the output signal with noise, separates the signal and noise contributions, and then computes the peak signal-to-RMS-noise ratio for direct indication of an S/N ratio. This sampling is accomplished on the baseband analog signal at the input to the data demodulator. The baseband analog signals are processed through the demodulator to the level comparators where the analog signal is quantized without regard to independent signal amplitudes. A typical optimized eye pattern at the output of the demodulator recovery unit is shown in figure 46-1.

e. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

f. The full application of this test to the AN/FRC-( ) cannot be determined at this time.

46-2. SPECIFICATIONS. The radio shall operate as specified in the standard engineering plan, contract specifications, or equipment technical manual.

46-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. Connectors, cables, attenuators, etc., as required.

c. Baseband sweep generator.

d. True RMS voltmeter.

46-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 46-2 and allow approximately 30 minutes for warmup and stabilization. On the AN/FRC-( ) the oscilloscope may also be connected to the eye pattern test point on demodulators A and B. If connected at the demultiplexer output (baseband), connect the oscilloscope to the MBS in use. To ensure that the observed crossings of the upper and lower patterns are referenced to the same bit, shift the patterns to the right until the origin of the trace can be seen. If both patterns originate in phase, the traces are correct.

b. With the oscilloscope, measure and adjust the demodulator or baseband output levels on both receivers until the levels are equal in amplitude.

c. Synchronize the oscilloscope from the baseband receive signal or demodulator output. If the test is performed at the demodulator output of the AN/FRC-( ), the test results will not include the hitless switch or delay compensating circuits within the demultiplexer.

d. Refer to the manufacturer's instructions or technical manual on the receiver for the proper method of varying the delay of one receiver with respect to the other. As these adjustments are made, observe the eye pattern of both receivers on the oscilloscope.

e. Continue the delay adjustments until similar points in each eye pattern are vertically above one another. When this adjustment is reached, the horizontal distance (Δ) between similar points is at a minimum and the two receivers are essentially in phase. Enter the value of (Δ) on figure 3-7 (DD Form 2091).

NOTE: It is important that the length of the two cables used to connect the oscilloscope to the receivers be exactly the same and that the characteristics be identical to preclude introducing additional differential delay.

f. If required, photograph the eye pattern and mount the photographs on figure 5-2 (DD Form 2093).

g. Typical eye patterns for the AN/FRC-( ) using quadrature partial response and quadrature phase shift keying are shown in figure 46-3. Figure 46-4 shows a typical eye pattern with phase difference (Δ).

46-5. DATA RECORDING AND ANALYSIS.

a. Review all test data to ensure that it meets equipment performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the receiver balance does not meet requirements, notify the responsible activity of required corrective actions.

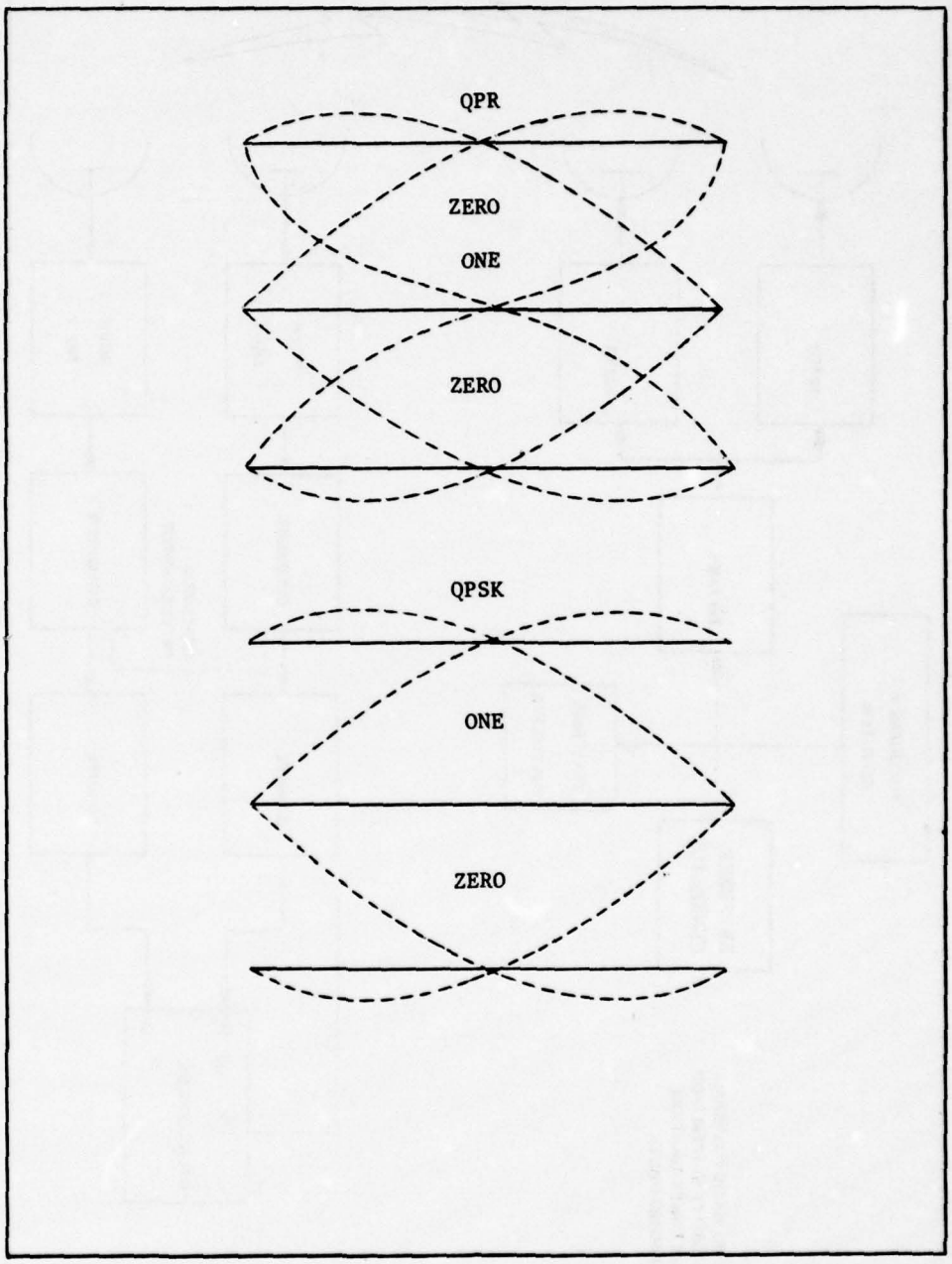


Figure 46-1. Simplified data recovery eye pattern.

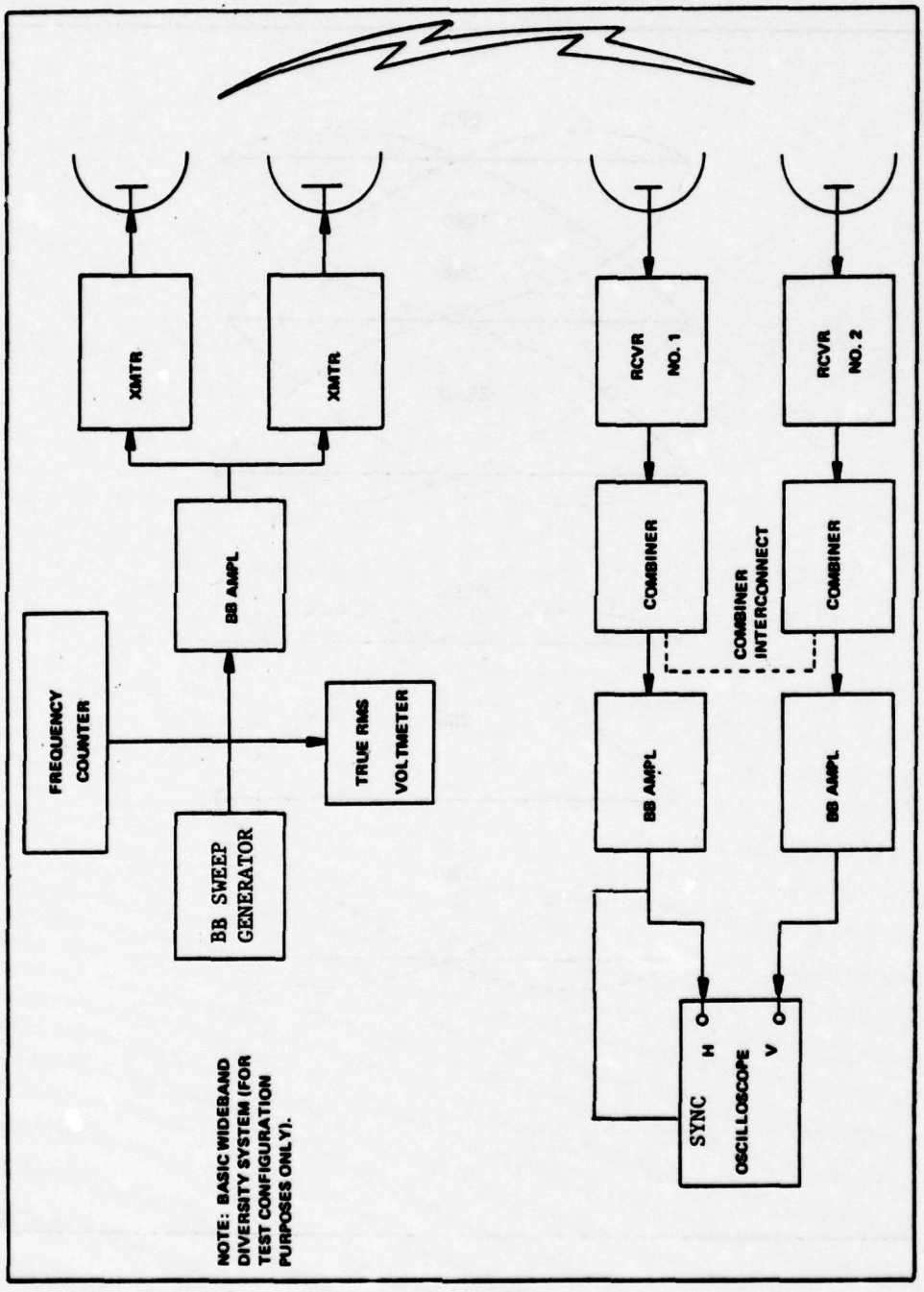


Figure 46-2. Receiver phasing test setup.

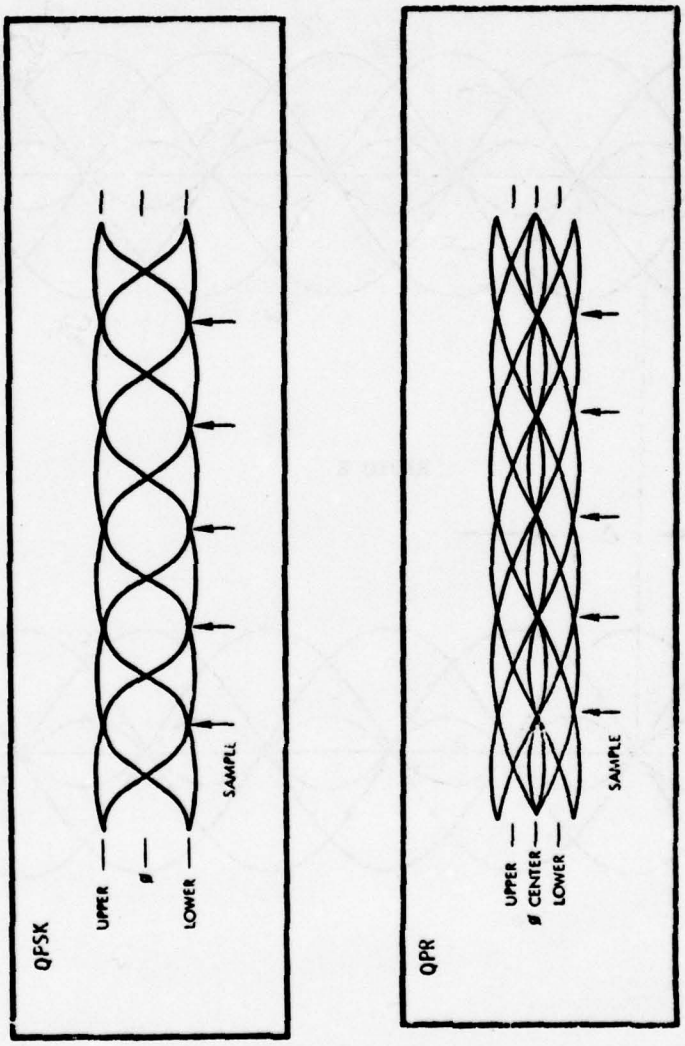


Figure 46-3. Typical eye patterns for the AN/FRC-( ).

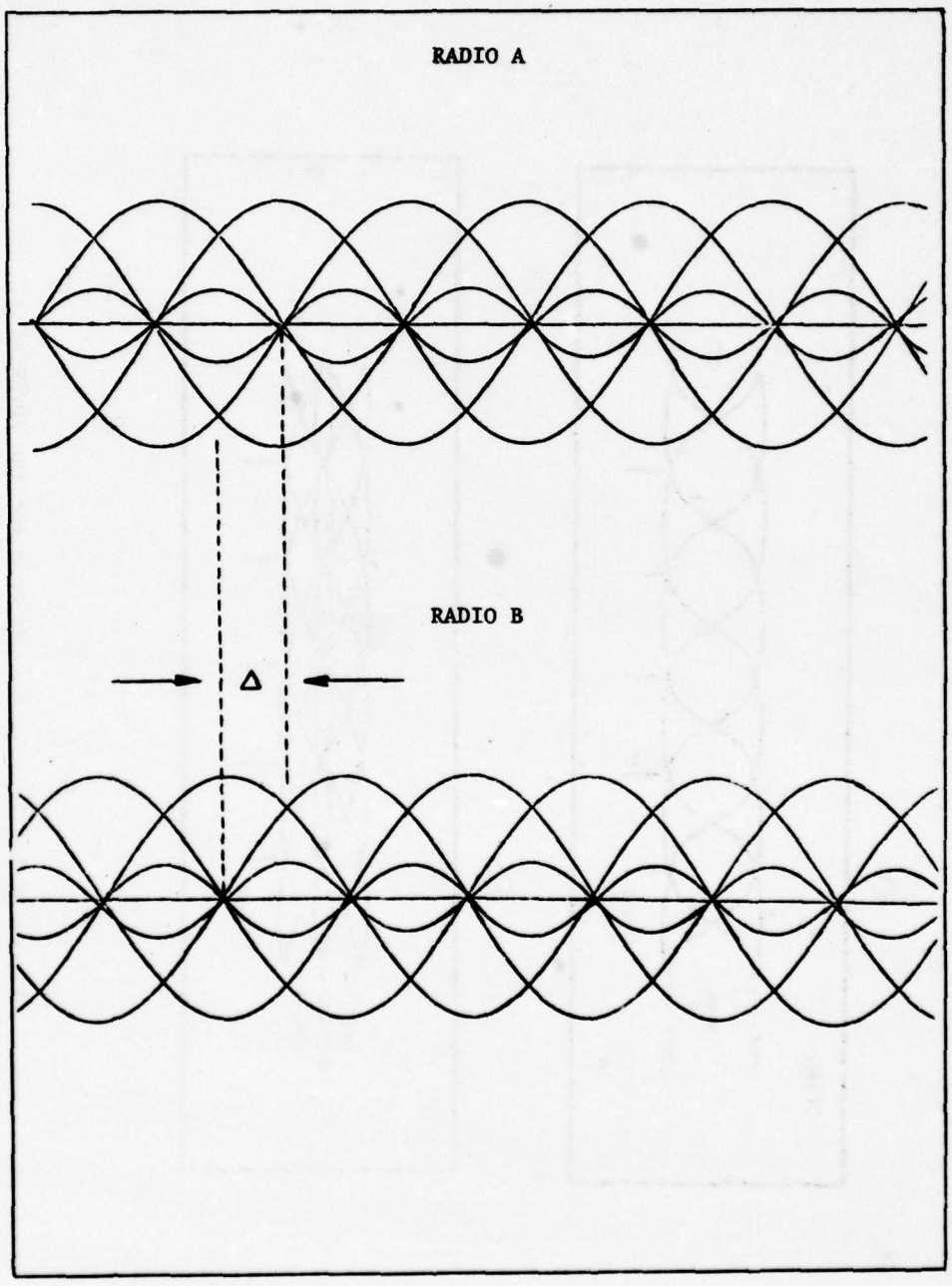


Figure 46-4. Typical eye pattern with phase difference.

CHAPTER 47

TEST TONE VARIATION (DT-244)

47-1. GENERAL.

a. The purpose of this test is to determine the stability of a three-level, partial-response test signal under the following conditions:

(1) Receive signal variations.

(2) Input power variations.

(3) Changes in environmental conditions.

b. This test is not applicable to the AN/FRC-( ); however, it can be adapted to this radio with only minor changes in the procedure.

c. If testing the AN/FRC-162 under the environmental conditions specified in paragraph 47-2, an environmental chamber will be required. For the purpose of field and onsite testing, the test should be performed under existing ambient temperature, humidity, and voltage.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

47-2. SPECIFICATIONS.

a. Variations in the AN/FRC-162 output level of a three-level, partial-response test signal shall not exceed ±0.25 volt for each and all of the following conditions: (SCCC-73017)

(1) Variations of signal level input to the receiver from -76 dBm to -15 dBm.

(2) Any input power variations from:

(a) Direct current power from 44 to 56 volts,

(b) Alternating current 120/240 volts, ±10 percent with a frequency of 47 to 63 Hz.

(3) Environmental conditions of:

(a) Temperature of 0 to 50 degrees Centigrade.

(b) Humidity of 0 to 95 percent.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

47-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Stepdown transformer.

c. Variable AC power source.

d. Frequency counter.

e. Digital multiplex/demultiplex.

f. Oscillator.

g. Recorder.

h. Turnaround mixer.

i. Voltmeter.

j. Attenuators, adapters, cables, and connectors, as required.

47-4. TEST PROCEDURES.

a. If this test is performed to demonstrate that the transmitter and receiver will provide specified performance within the temperature and humidity range outlined in paragraph 47-2, place the unit in an environmental test chamber. If performed as a field test, omit those portions requiring a test chamber.

b. Connect the test equipment as shown in figure 47-1 and allow approximately 1 hour for warmup and stabilization.

c. Initially strap the transmitter and receiver for DC and adjust the primary DC supply for -48 VDC.

d. Adjust the output of the pattern generator to the baud rate of the equipment under test at a level of 1±0.25 VPP. If using a digital multiplex as the transmit input source, adjust the multiplex output for 1 VPP. Connect the oscillator to one of the channels of the digital multiplex and adjust its output to 1 kHz at a level of -10 dBm.

e. Adjust AT-1 for a safe operating level into the turnaround mixer and initially adjust AT-2 for an RSL of -30 dBm. If this test is being performed on a link basis, omit AT-1 and the turnaround mixer.

f. At the receive end, measure and record the baseband output level or MSB-1 out on the AN/FRC-( ). The level should be 1±0.25 VPP. If not, the transmitter and receiver should be adjusted to provide the correct level. If using a digital multiplex and an oscillator, measure and record the -10 dBm test tone at the receive terminal.

g. Once the levels have been verified as correct, calibrate one channel of the chart recorder for a range of 2 volts full-scale if recording the baseband signal level, or 4 dB full-scale if recording the -10 dBm test tone.

h. Calibrate the 2d channel of the recorder for 44 to 56 VDC, and the 3d recorder channel for 120 or 240 VAC, ±10 percent. If the AC input frequency is also being recorded, calibrate the recorder between 47 and 63 Hz.

i. Once the calibration sequence has been completed, perform the following sequences and record the results on figure 47-2 (USACC Form 647-R).

(1) With AT-2, adjust the RSL to -15 dBm. Adjust the DC input power to the transmitter and receiver to -44 VDC. Record the results for 15 minutes and note that the recorded 1-kHz test tone or baseband level remains within -10 dBm ±0.25 dB of the input signal. If recording the baseband, verify that the level remains at 1±0.25 VPP.

(2) Change the primary DC input power to -56 VDC and repeat subparagraph (1), above.

(3) Adjust the RSL to -76 dBm and repeat subparagraphs (1) and (2), above.

(4) Change the input power to the transmitter to 120 VAC, ensuring that all required straps within the equipment have been accomplished.

(5) Adjust the RSL to -15 dBm and the input AC power to 108 VAC at a frequency of 47 Hz. Record the stability of the 1-kHz test tone or baseband level for 15 minutes. Change the frequency of the primary AC power to 63 Hz and again record the results for 15 minutes.

(6) Change the AC input power to 132 VAC and repeat subparagraph (5), above.

(7) Change the straps on the radio set for 240 volts and repeat subparagraphs (5) and (6), above, with the input power adjusted to 216 and 264 VAC.

(8) Adjust the RSL to -76 dBm and repeat subparagraphs (5) through (7), above.

j. If this test is performed as part of an equipment acceptance test at a contractor's facility, repeat the entire procedure at the environmental conditions specified for the equipment.

47-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for accuracy, completeness and compliance with specified requirements. Complete all applicable portions of the data sheet. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

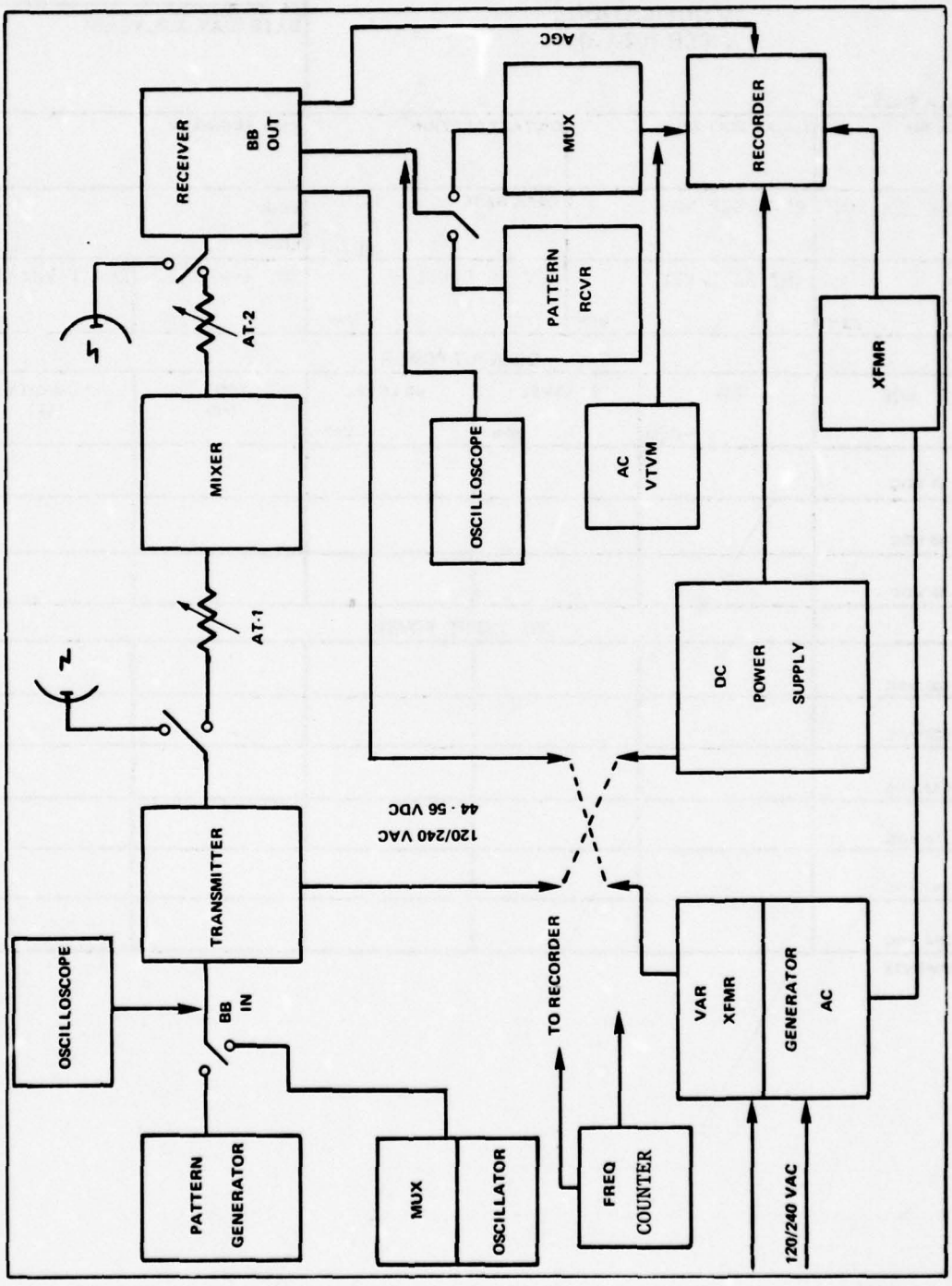


Figure 47-1. Test tone variation (AN/FRC-162) test setup.

POWER REQUIREMENTS VERIFICATION (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YEAR)	
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER	
XMTR SER NO.	RCVR SER NO.	DATA RATE mb/s	LINK ☐ LOOP ☐	
RSL dBm	XMT BB LEVEL VPP	RCV BB LEVEL VPP	XMT 1-kHz TT dBm	RCV 1-kHz TT dBm

DC INPUT POWER					
RQR	RSL -dBm	TT LEVEL dBm	BB LEVEL VPP	TEMP (°C)	HUMIDITY (%)
44 VDC					
48 VDC					
56 VDC					
	AC INPUT POWER				
108 VAC					
120 VAC					
132 VAC					
216 VAC					
240 VAC					
264 VAC					

COMMENTS

USACC FORM 647-R
1 MAY 79

Figure 47-2. Power requirements verification data sheet.

CHAPTER 48

INPUT POWER VERIFICATION (DT-245)

48-1. GENERAL.

a. The purpose of this test is to determine if the equipment provides specified performance under different levels of primary input power.

b. This test is not applicable to the AN/FRC-162.

c. If this test is being performed in a field environment, it is not practical to verify the performance of the radio set under all temperature and humidity conditions. Therefore, during field testing, the test would normally be performed under existing environmental conditions.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. If performed at a contractor's facility to verify that the radio set being delivered meets all performance requirements, it will be necessary to control the environmental conditions throughout the test period.

48-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) The radio shall operate and maintain specified performance when connected to a DC power source having any output voltage from -44 to -56 VDC. Ripple and noise shall not exceed 100 mV peak-to-peak.

(2) The radio shall operate under the following environmental conditions.

(a) Temperature range of 0 to 49 degrees Centigrade.

(b) Humidity range of up to 95 percent.

(c) Altitude of up to 15,000 feet.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

48-3. TEST EQUIPMENT REQUIRED.

a. MBS pattern test set.

b. SCBS pattern test set.

c. Oscilloscope.

d. Turnaround mixer.

e. Voltmeter.

f. Recorder.

g. Noise generator oscillator.

h. Environmental chamber with sensors.

i. Attenuators, connectors, cables, etc., as required.

48-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 48-1 and allow approximately 1 hour for warmup and stabilization. Omit the turnaround mixer if the transmitter and receiver are tuned to the same frequency.

b. Set the MBS pattern generator to the designed baud rate of the equipment under test at a level of 1 VPP. If the same radio set is to be used for those transmission rates shown in table 48-1, change those frequency limiting components of the radio to accommodate each of the required transmission rates.

c. Set the service channel pattern generator to 192 kb/s at a level of 1 VPP.

d. Adjust AT-1 (fig. 48-1) for a safe operating level into the mixer and adjust AT-2 for an RSL corresponding to a BER of $5x10^{-9}$. This can be calculated from the following formula:

PERFORMANCE LEVEL I

RSL	RSL FOR A BER OF
$-164 + 10 \log_{10} R + NF$	$5x10^{-2}$
$-157 + 10 \log_{10} R + NF$	$5x10^{-9}$

PERFORMANCE LEVEL II

$-158 + 10 \log_{10} R + NF$	$5x10^{-2}$
$-151 + 10 \log_{10} R + NF$	$5x10^{-9}$

Where:

R = aggregate bit rate
NF = receiver noise figure

e. If the test is being performed at a contractor's facility, connect the environmental temperature and humidity sensors to the calibrated recorder. Also connect the previously calibrated AGC voltage of the radio to the recorder as shown in figure 48-1. If the AGC has not previously been calibrated for AGC versus RSL, perform DT-224.

f. Adjust the external DC power supply output for -44 VDC with ripple and noise components of 100 mV peak-to-peak.

g. Transmit data at the applicable bit rate for 15 minutes. Note at the receive end that the recorded data meets or exceeds the $5x10^{-9}$ requirement.

h. With AT-2, adjust the RSL to a value corresponding to a BER of $5x10^{-2}$ as outlined in subparagraph d, above, and transmit data for 15 minutes. At the receiver, note that the BER meets or exceeds the $5x10^{-2}$ requirement.

i. Change the transmitter and receiver input DC power to -56 VDC with noise and ripple not exceeding 100 mV peak-to-peak and repeat subparagraphs g and h, above.

j. If performed where an environmental chamber is available, repeat subparagraphs f through i, above, at the temperature and humidity range as shown in paragraph 48-2, above.

k. Record all test results on figure 48-2 (*USACC Form 648-R*).

48-5. DATA RECORDING AND ANALYSIS.

a. Review all test results to ensure that they meet specified performance requirements and that the test data is complete and accurate. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

Table 48-1. General Characteristics (AN/FRC-( ))

PARAMETER	PERFORMANCE CHARACTERISTIC
RADIO	
Frequency range	4.4 to 5 GHz, 7.125 to 8.4 GHz
Carrier frequency stability	0.0005% for specified environment
MBS rates	3.2 to 12.9 mb/s
Service channel rate	192 kb/s
Total system data rates	3.5 to 26.1 mb/s
Bandwidth efficiency	2 bits/Hz QPR, 1 to 1.3 bits/Hz QPSK
Prime power	-50±6 VDC
TRANSMITTER	
Output power	0.1 to 2 watts
Frequency source	Crystal reference source
IF interface	70 MHz
Modulation	QPR or QPSK
RECEIVER	
Noise figure	10 dB maximum
Local oscillator	Crystal reference source
IF interface	70 MHz
MODULATOR SECTION	
Input data	Serial NRZ (unbalanced)
Input clock	Square wave (unbalanced)
Aggregate bit rates	3.488, 6.720, 9.952, 13.184, 19.648, 26.112 mb/s
IF interface	70 MHz, -15 dBm into 50 ohms
Base bandwidth	3.5, 7, 10.5, 14, 20 MHz by plug-in filters
DEMODULATOR SECTION	
Output data	Serial NRZ (unbalanced)
Output clock	Square wave (unbalanced)
Aggregate bit rates	Same as modulator section
Base bandwidth	Same as modulator section
IF interface	70 MHz, 0 dBm into 50 ohms
IF bandwidth	Two times transmitted bandwidth

Table 48-1. General Characteristics (AN/FRC-( ))
(continued)

PARAMETER	PERFORMANCE CHARACTERISTIC
RECONFIGURATION TO ACCOMMODATE DIFFERENT DATA RATES	
Data interface unit	No changes required
Modulator unit	1) Exchange baseband filter and equalizer plug-in unit 2) Strap selectable baseband filter driver configuration
Demodulator unit	1) Exchange baseband filter plug-in 2) Exchange IF filter plug-in 3) Strap selectable modulation estimator level slicer 4) Strap selectable multiplier gain adjust
Data recovery unit	1) Strap selectable comparator level threshold 2) Strap selectable data decoder algorithm 3) Exchange clock crystal 4) Strap selectable sampler delay
Signal quality unit	1) Strap selectable output scaler 2) Strap selectable programer
RF section	1) Exchange four bandpass filters 2) Exchange two circulators 3) Exchange two transmitter switches 4) Exchange two diplexers 5) Exchange or adjust two STALOS 6) Adjust automatic level control 7) Exchange flange or EMI cover at antenna port
Multiplexer	1) Switch selectable 1 or 2 MBS 2) Strap selectable divider controls 3) Exchange three clock crystals

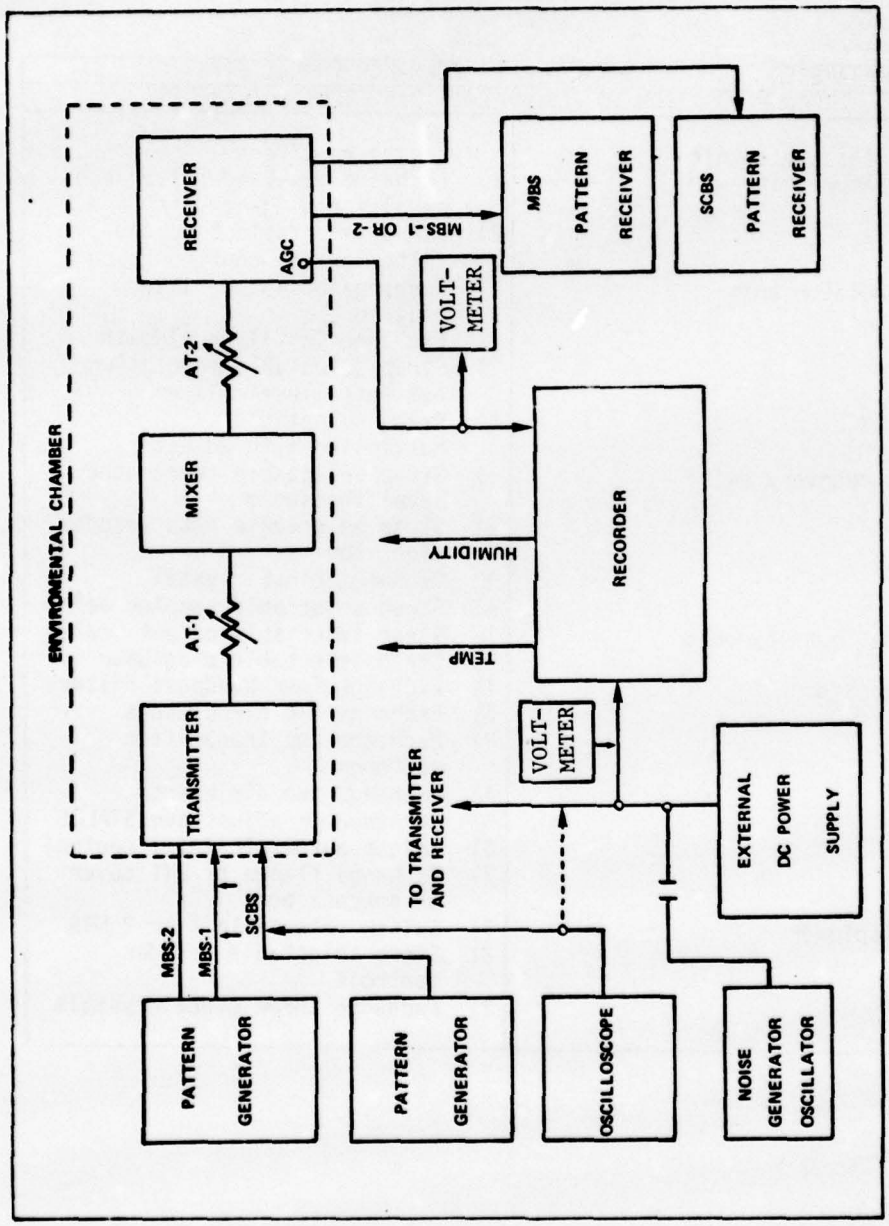


Figure 48-1. Input power (AN/FRC-( )) test setup.

DIGITAL RADIO INPUT POWER AND PERFORMANCE (CCR 702-1-3)			PAGE OF PAGES
DATA SHEET			DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	NOISE AND RIPPLE mV	AGGREGATE BIT RATE mb/s

TRANSMIT		RECEIVE	
SCBS VPP	MBS VPP	SCBS VPP	MBS VPP

TEST REQUIREMENT	TEMP (°C)/HMD (%)	BER	TEST RESULTS
-44 VDC	0/0	$5x10^{-9}$	
		$5x10^{-2}$	
-44 VDC	49/95	$5x10^{-9}$	
		$5x10^{-2}$	
-56 VDC	0/0	$5x10^{-9}$	
		$5x10^{-2}$	
-56 VDC	49/0	$5x10^{-9}$	
		$5x10^{-2}$	
-44 VDC	LOCAL CONDITIONS	$5x10^{-9}$	
		$5x10^{-2}$	
-56 VDC	LOCAL CONDITIONS	$5x10^{-9}$	
		$5x10^{-2}$	

COMMENTS

USACC FORM 648-R
1 MAY 79

Figure 48-2. Digital radio input power and performance data sheet.

CHAPTER 49

RADIO TRANSIENT PROTECTION
(DT-246)

49-1. GENERAL.

a. The purpose of this test is to determine the radio performance under conditions of transient voltage variations, frequency excursions, and DC spikes.

b. This test does not apply to the AN/FRC-( ).

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. Normally, however, it would not be performed in a field test environment.

d. If the AN/FRC-162 is designed for only DC input power, portions of this test will not apply.

49-2. SPECIFICATIONS.

a. The AN/FRC-162 shall not suffer damage or degradation and shall provide specified performance within 5 seconds after being subjected to the following transient conditions for a period not to exceed 500 msec except where otherwise noted: (SCCC-73017)

(1) Any degree of undervoltage.

(2) Specified voltage or less at any frequency between 40 and 70 Hz for a nominal 60-Hz supply.

(3) AC voltage variations of ±30 percent from any point within the ±10 percent tolerance range.

(4) DC input spikes up to 150 volts for up to 10 msec.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

49-3. TEST EQUIPMENT REQUIRED.

a. Test fixture, overvoltage.

b. Test fixture, undervoltage.

c. Test fixture, DC spikes.

d. Test fixture, transients.

e. Oscilloscope.

f. Voltmeter.

g. Directional couplers.

h. Autotransformer.

i. Adapters, connectors, attenuators, and cables, as required.

49-4. TEST PROCEDURES.

a. General. Connect the radio for back-to-back operation as shown in figure 49-1. Perform the following tests to establish a baseline for determining if the radio provides specified performance at the conclusion of this test.

(1) Transmit output power (DT-233).

(2) Transmit frequency (DT-236).

(3) Pilot frequency (DT-217).

(4) Test tone variation (DT-244).

b. Undervoltage Transients.

(1) With the radio configured as shown in figure 49-1, connect the AC power input as shown in figure 49-2a, with all power to the radio turned off.

(2) Adjust the slider on R1 for 12 ohms as measured from the slider to the radio side of R1.

(3) Apply primary AC power to the radio under test and allow approximately 30 minutes for warmup and stabilization.

(4) Operate S1 on the undervoltage test fixture and note that K1 cycles. This action induces a nominal 30-percent low voltage transient into the radio set powerline.

(5) After 5 seconds, inspect the radio for damage. If none is apparent, open switch S2 and again operate S1 on the undervoltage test fixture. Note that K1 cycles. This action induces a nominal 55-volt low transient into the radio under test.

(6) After 5 seconds, inspect the radio for damage. If none is apparent, remove the test fixture and reconnect the radio to the AC powerline.

(7) Reapply power to the radio set and allow approximately 30 minutes for warmup and stabilization. Perform the test outlined in subparagraph a, above, to determine if there has been any damage or degradation. Record the results on figure 49-3 (USACC Form 649-R).

c. Overvoltage Transients.

(1) Connect the radio for back-to-back operation as shown in figure 49-1. Connect the AC power input to the radio as shown in figure 49-2b, with all power to the radio under test turned off.

(2) Adjust the slider on R1 for 12 ohms, measured from the slider to the radio side of R1.

(3) With the radio breakers off, adjust the autotransformer output voltage to 150 VAC. Turn the radio circuit breakers on and verify that the input voltage to the radio set is 115 VAC ±10 percent.

(4) On the overvoltage test fixture (fig. 49-2b), operate S1 and note that K1 cycles. This action induces a nominal 30-percent high voltage transient into the radio input power.

(5) After 5 seconds, inspect the radio for damage. If none is apparent, return the radio power input terminals to their normal configuration (test fixture removed and the radio connected to the AC power source).

(6) Reapply power to the radio under test and allow approximately 30 minutes for warmup and stabilization.

(7) Perform the tests outlined in subparagraph a, above. Record the results on figure 49-3 (USACC Form 649-R).

d. DC Input Spikes.

(1) Connect the radio for back-to-back operation as shown in figure 49-1.

(2) Perform the following adjustments on the DC spike test fixture as shown in figure 49-4.

(a) Adjust T1 for 150 VPP spikes across R2 when switch S1 is activated.

(b) Verify that K1 operates at 8±2 msec when switch S1 is closed.

(c) Adjust transformer T2 for 115 VAC across resistor R2.

(d) Trun off all power to the test fixture and remove resistor R2.

(3) Apply power to the radio and verify that 115 VAC is present at the radio input terminals.

(4) Allow approximately 30 minutes for warmup and stabilization. Operate switch S1 on the DC spike test fixture and note that K1 cycles. This action should induce a 150 VPP spike into the radio input power circuit.

(5) After 5 seconds, inspect the radio for any damage. If none is apparent, return the powerlines to their normal configuration (remove the DC spike test fixture and reconnect the AC powerlines to the radio).

(6) Reapply power to the radio and allow approximately 30 minutes for warmup and stabilization. Perform the tests outlined in subparagraph a, above. Record the results on the data sheet.

e. Frequency Transients.

(1) Connect the radio for back-to-back operation as shown in figure 49-1.

(2) Connect the frequency transient test fixture as shown in figure 49-5. Apply power to the radio.

(3) After the radio has stabilized, adjust variable frequency power source #2 to 50 Hz and fixed frequency power source #1 to 60 Hz.

(4) Operate the switch S1 on the test fixture and note that K1 cycles. This should induce a -10 Hz low frequency transient into the radio powerlines.

(5) After 5 seconds, inspect the radio for damage. If none is apparent, adjust variable frequency source #2 to 70 Hz.

(6) Operate switch S1 on the test fixture and note that relay K1 cycles. This should induce a 10-Hz high frequency transient into the radio powerlines.

(7) After 5 seconds, inspect the radio for damage. If none is apparent, perform the tests outlined in subparagraph a, above. Record the results on the data sheet.

49-5. DATA RECORDING AND ANALYSIS.

a. Record all pertinent data on figure 49-3 (USACC Form 649-R). Use additional sheets, as required for each test sequence and radio to be tested. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified performance requirements or was damaged during one of the test sequence, notify the responsible activity of required corrective actions.

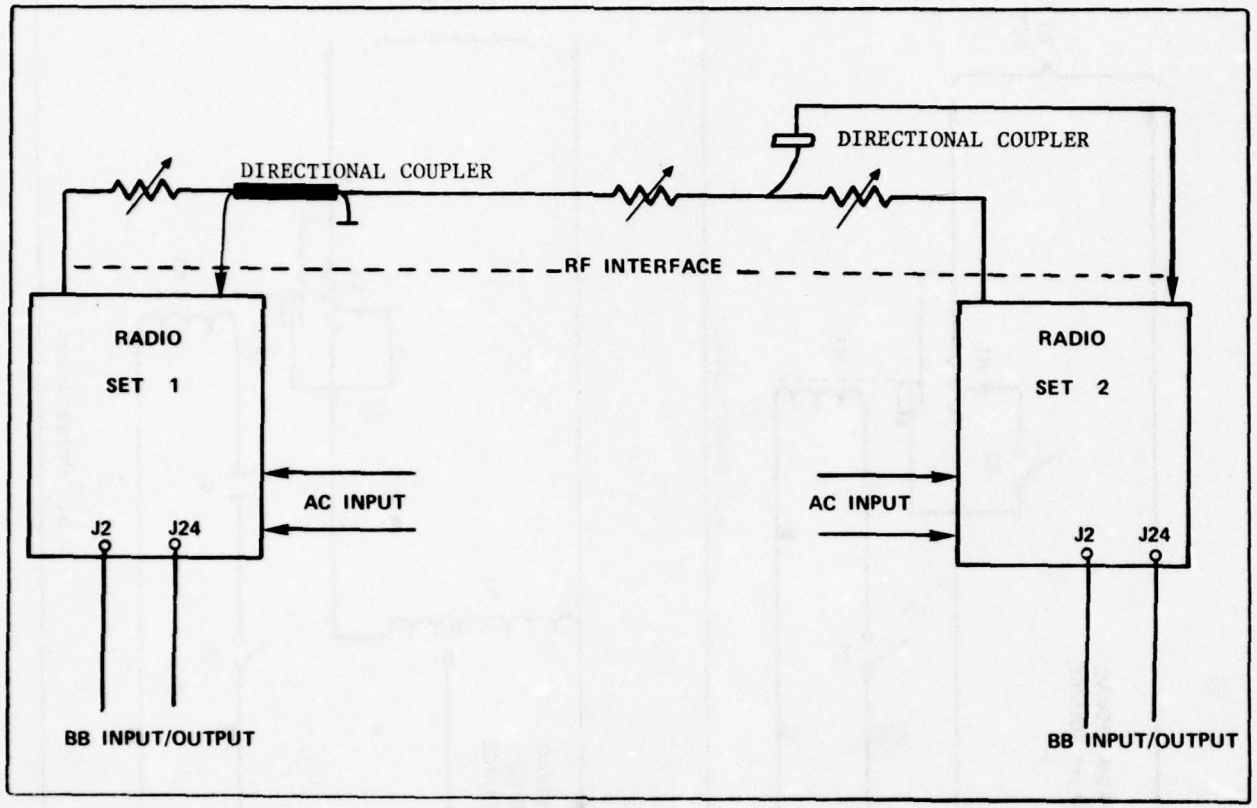


Figure 49-1. Radio receiver-transmitter transient protection test setup.

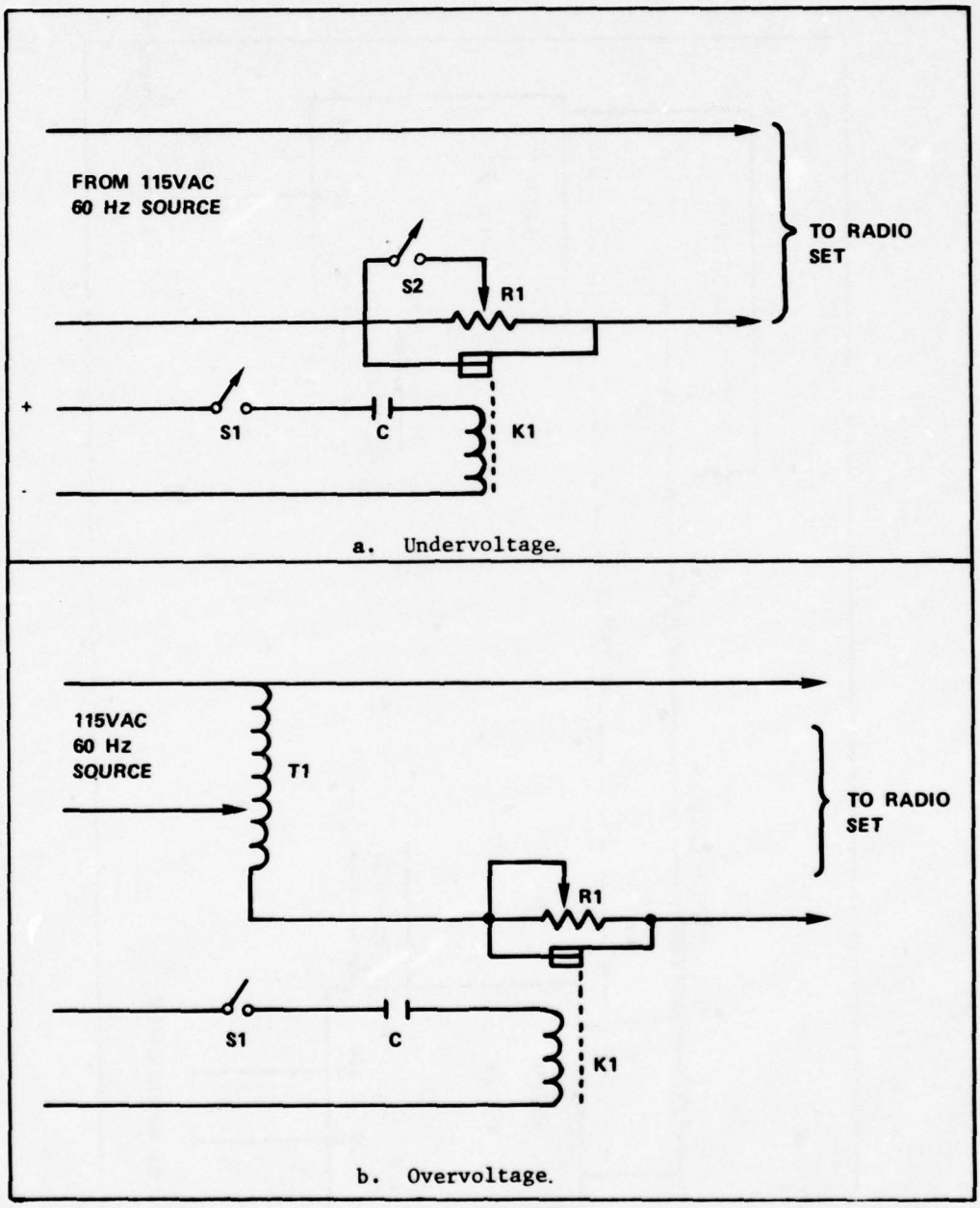


Figure 49-2. Voltage variations test setup.

TRANSIENT PROTECTION (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	TEST PERFORMED	

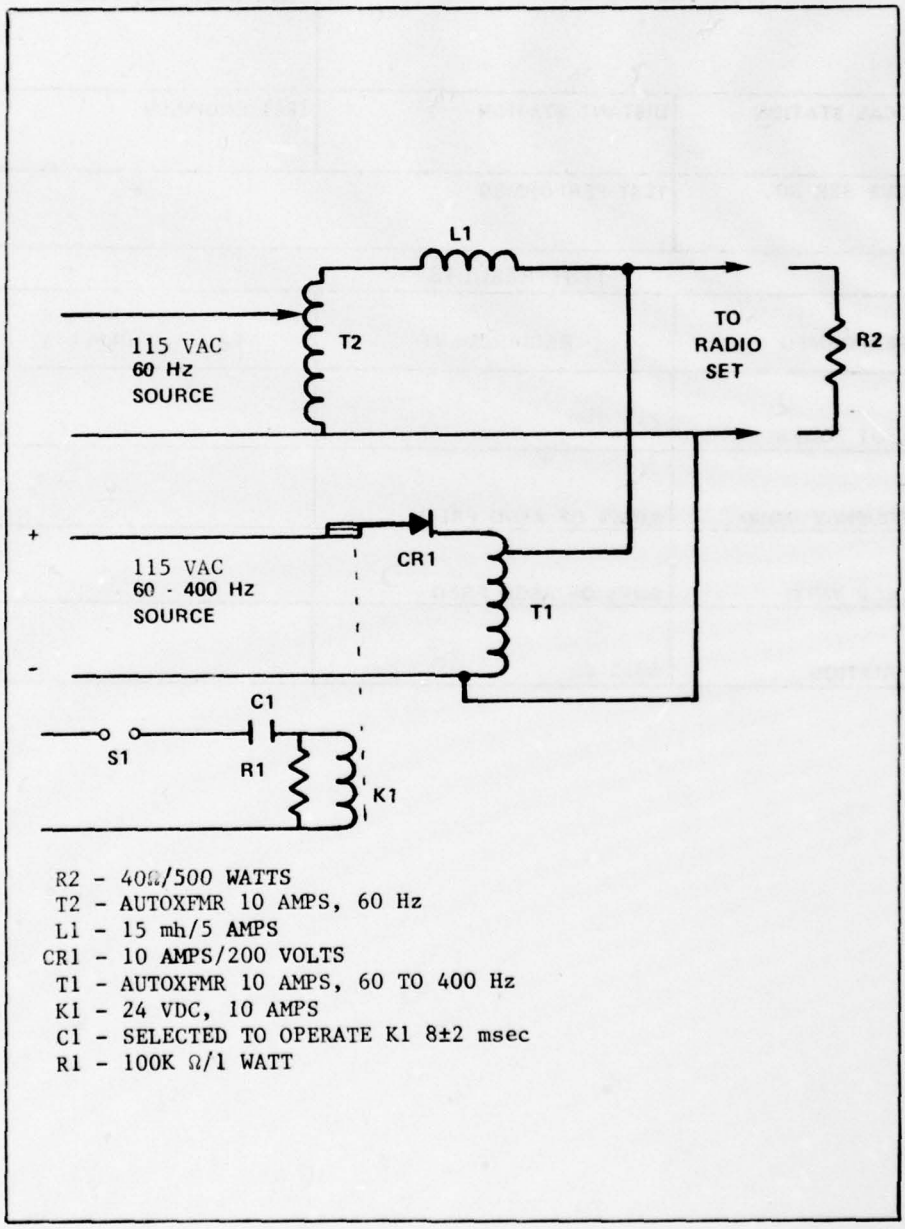
TEST RESULTS

TEST PERFORMED	REQUIREMENT	MEASURED RESULTS
TRANSMIT OUTPUT POWER	≥27 dBm	dBm
TRANSMIT FREQUENCY (MHz)	0.005% OF ASGD FREQ	%
PILOT FREQUENCY (MHz)	0.01% OF ASGD FREQ	%
TEST TONE VARIATION	±0.5 dB	dB

COMMENTS

USACC FORM 649-R
1 MAY 79

Figure 49-3. Transient protection data sheet.



R2 - 40Ω/500 WATTS
T2 - AUTOXFMR 10 AMPS, 60 Hz
L1 - 15 mh/5 AMPS
CR1 - 10 AMPS/200 VOLTS
T1 - AUTOXFMR 10 AMPS, 60 TO 400 Hz
K1 - 24 VDC, 10 AMPS
C1 - SELECTED TO OPERATE K1 8±2 msec
R1 - 100K Ω/1 WATT

Figure 49-4. DC spike test fixture.

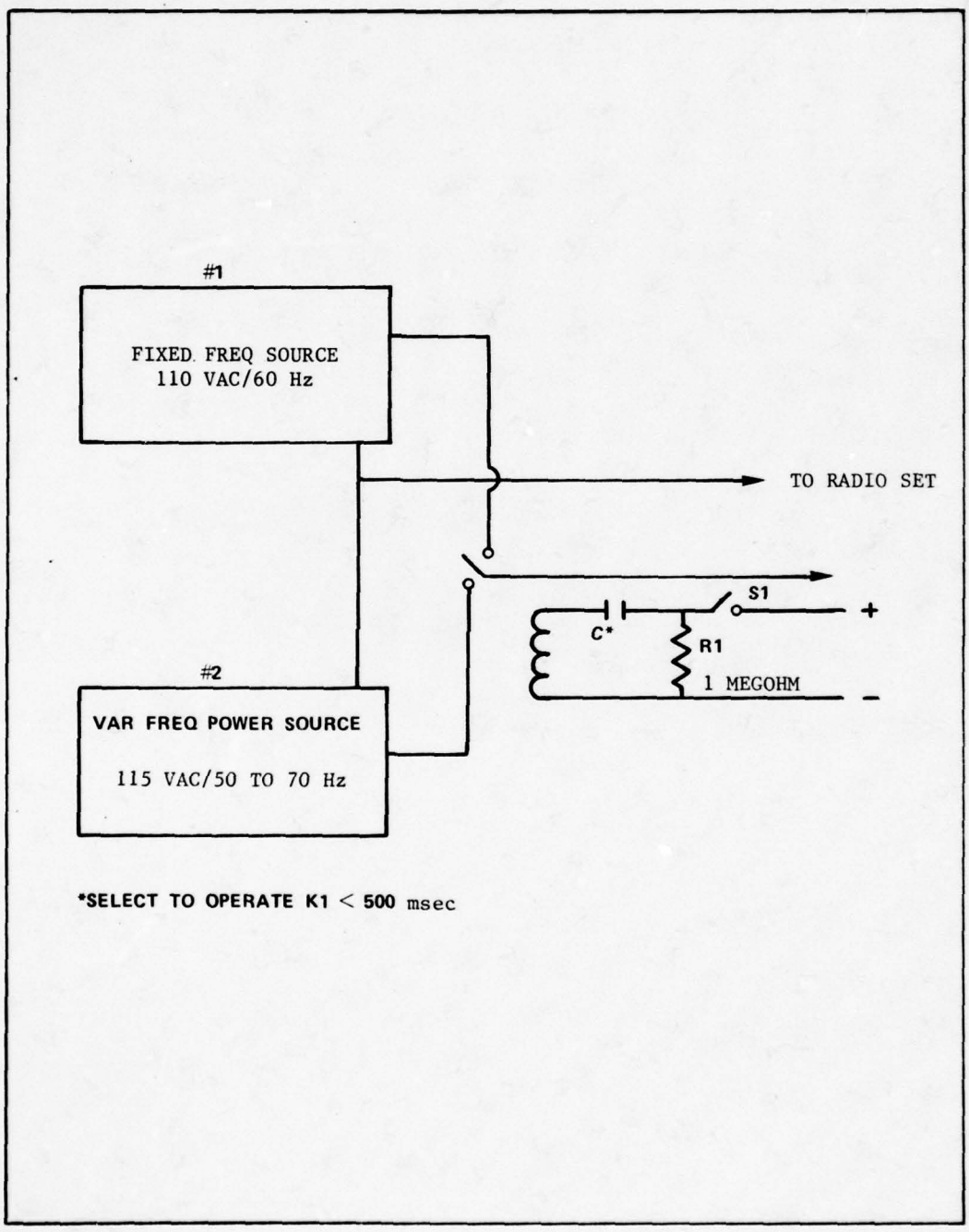


Figure 49-5. Frequency transient test fixture.

CHAPTER 50

REVERSE POLARITY PROTECTION (DT-247)

50-1. GENERAL.

a. The purpose of this test is to determine if the DC voltage input circuits of the radio are protected if a reverse polarity condition should inadvertently be applied to the input.

b. This test is applicable to the AN/FRC-162 and AN/FRC-( ) that will enter the inventory at a later date.

c. This test may be performed during field test activities; however, it is more applicable to equipment acceptance at a contractor's or production facility.

50-2. SPECIFICATIONS.

a. The radio terminal equipment shall suffer no damage from, and shall provide specified performance after, removal of a reversed polarity condition. (MIL-STD-188-322)

b. Reverse polarity protection shall be provided for DC inputs. The equipment (AN/FRC-162) shall suffer no damage from, and shall provide specified performance after, removal of the reverse polarity condition. (SCCC-73017)

c. Reverse polarity protection shall be provided for DC inputs. The equipment (AN/FRC-( )) shall suffer no damage from, and shall provide specified performance after, correction of the reverse polarity condition. (CCC-74049)

d. The radio shall operate as specified in the standard engineering plan or contract specifications.

50-3. TEST EQUIPMENT REQUIRED.

a. Voltmeter.

b. 48-VDC power supply, Sorenson.

50-4. TEST PROCEDURES.

a. Before performing this test, a baseline of performance characteristics should be established by performing and recording the test results of the following test sequences.

(1) Transmitter output power (DT-233).

(2) Modulator/demodulator linearity (AN/FRC-162 only) (DT-234 and DT-235).

(3) Test tone variation (AN/FRC-162 only) (DT-244).

(4) Receiver small signal performance (AN/FRC-( ) only) (DT-226).

(5) Bit error rate (AN/FRC-162 only) (DT-249).

b. Connect the radio in a back-to-back loop as shown in figure 50-1. Allow approximately 30 minutes for warmup and stabilization. Perform those tests that are applicable as listed in subparagraph a, above, unless they have already been completed and the results properly recorded. Omit the turnaround mixer if the transmitter and receiver are tuned to the same frequency.

c. Turn off the radio and disconnect the external DC power source. Reverse the DC polarity to the radio. On the AN/FRC-162, connect the positive output of the test power supply to pin A to J101/J102 (A or B radio) and the negative output to pin C, J101/J102. On AN/FRC-( ), connect the test power supply to the DC bus A or B. Refer to the equipment manual for the specific terminals.

d. Set the test power supply to limit at 4 amperes DC and turn on all radio circuit breakers and power supply switches. Maintain the reverse power conditions for approximately 30 seconds.

e. Remove the reverse power condition and reconnect the radio to the regular external DC supply.

f. Perform the applicable test listed in subparagraph a, above. Record the results on figure 50-2 (USACC Form 650-R).

g. Repeat the above procedures for other radios to be tested.

50-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for accuracy, completeness, and compliance with requirements. Summarize all test results on figure 3-7 (DD Form 2091).

b. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

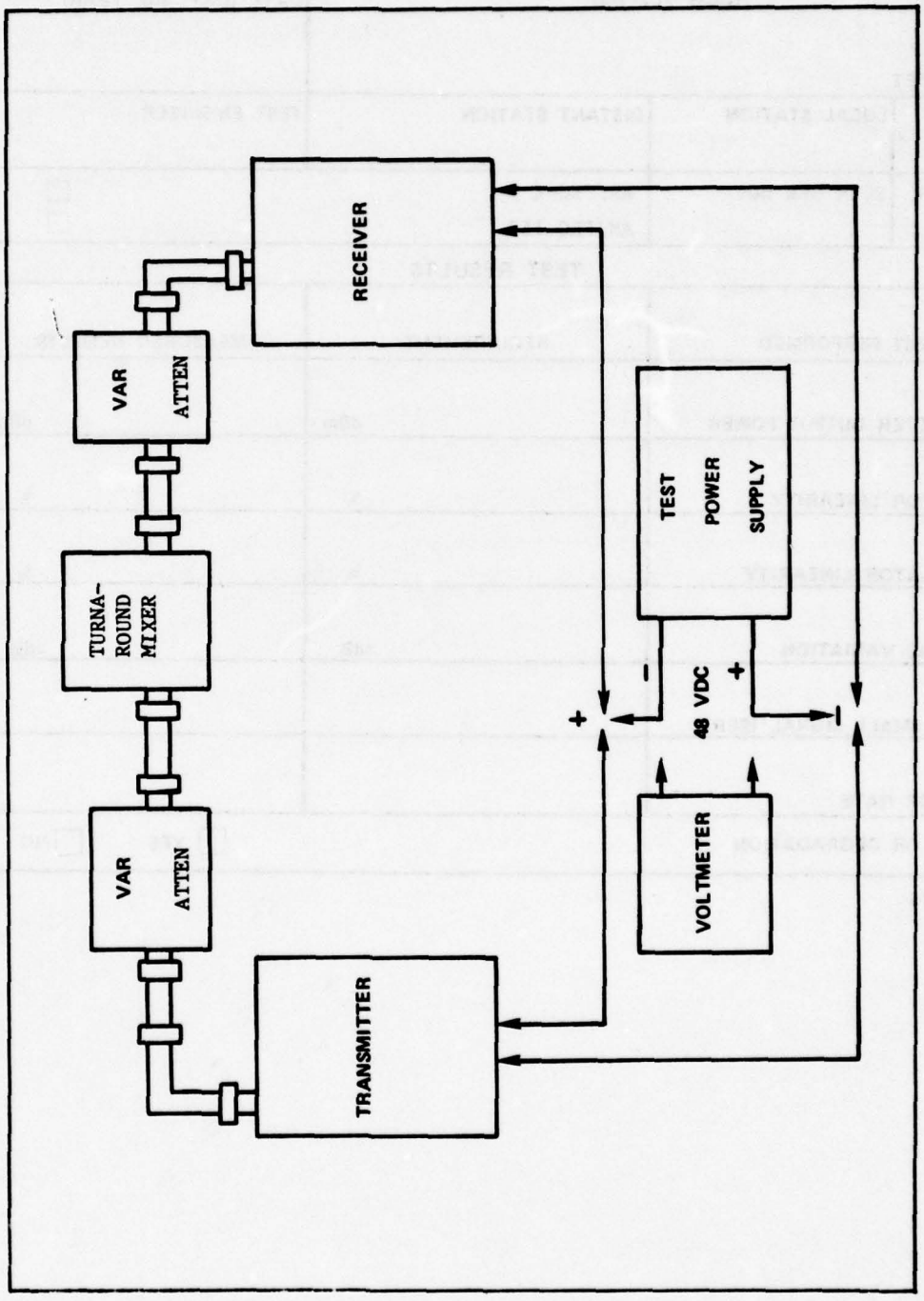


Figure 50-1. Reverse polarity test setup.

REVERSE POLARITY (CCR 702-1-3)			PAGE OF PAGES
DATA SHEET			DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	AN/FRC-( ) ☐ AN/FRC-162 ☐	

TEST RESULTS		
TEST PERFORMED	REQUIREMENT	MEASURED RESULTS
TRANSMITTER OUTPUT POWER	dBm	dBm
MODULATOR LINEARITY	%	%
DEMODULATOR LINEARITY	%	%
TEST TONE VARIATION	±dB	±dB
RECEIVE SMALL SIGNAL (BER)		
BIT ERROR RATE		
DAMAGE OR DEGRADATION		☐ YES ☐ NO

COMMENTS

USACC FORM 650-R
1 MAY 79

Figure 50-2. Reverse polarity data sheet.

CHAPTER 51

POWER SUPPLY PROTECTION (DT-248)

51-1. GENERAL.

a. The purpose of this test is to determine if the transmitter and receiver of the AN/FRC-( ) are protected from input power overloads.

b. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be performed by installer or quality assurance personnel during onsite test activities as directed. The application of this test to onsite activities; however, should be limited to those instances where there is an apparent problem with the radio.

c. This test may be performed on the AN/FRC-162; however, there are no specified requirements on which to base a comparison of the measured test results.

51-2. SPECIFICATIONS.

a. Each transmitter, receiver, and all other unit(s) (AN/FRC-( )) shall be protected against overload separately to prevent one unit from affecting others. Removal or failure of a power supply shall cause no interruption or degradation of service provided by the radio. In addition, the radio shall not be damaged nor shall it sustain a service outage in excess of 100 msec as a result of the application of a 1000-volt potential of either polarity for a period of 1.0 µsec, applied to all input power interfaces and ground. Human intervention shall not be required to return the radio to service after the application of the specified transient. (CCC-74049)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

51-3. TEST EQUIPMENT REQUIRED.

a. Variable attenuators, as required.

b. Oscilloscope.

c. MBS BER test set.

d. SCBS BER test set.

e. Test fixture (transient voltage).

f. Connectors, cables, amd adapters, as required.

g. Turnaround mixer (if transmitter and receiver are tuned to different frequencies).

51-4. TEST PROCEDURES.

a. Transient Protection.

(1) Connect the radio in a back-to-back RF loop as shown in figure 51-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Adjust the turnaround mixer for the center frequency of the radio receiver. With the variable attenuator, ensure a safe operating level into the mixer is not exceeded. Adjust the receive attenuator to provide an RSL equivalent to a BER of $5x10^{-2}$. Tables 29-4 and 29-5 can be used as guides to select the RSL for different configurations of the radio. Transmit data for 15 minutes and note that the received data is within the $5x10^{-2}$ requirement.

(3) Turn off the radio and the external DC voltage supply. Connect the test fixture to the radio DC bus.

NOTE: The test fixture must provide a 1000-volt transient for 1.0 µsec at a 50-volt nsec rate.

(4) Turn on the external DC voltage to the radio and all equipment breakers and switches. Allow approximately 30 minutes for warmup and stabilization. Transmit data at the applicable bit rate for approximately 15 minutes.

(5) Calibrate the oscilloscope to display a 100-msec time interval and connect the trigger input to the test fixture.

(6) With the test fixture, provide a 1000-volt transient pulse across the radio DC interface point. Note that the data pattern has stabilized within 100 msec and the received data meets or exceeds the BER of $5x10^{-2}$.

(7) Remove the test fixture and restore the radio to its normal DC voltage supply.

b. Overload Protection.

(1) Adjust the RSL for a reading equivalent to a BER of $5x10^{-9}$ with the receive waveguide attenuator.

(2) While transmitting data, perform the sequences listed below on radio A. Observe that there is no loss of synchronization or affect on the received data stream. In sequence and one at a time, momentarily remove the following equipment fuses and note that a failure indicator activates.

(a) Multiplexer.

(b) Demultiplexer.

(c) Modulator.

(d) Demodulator.

(e) Receiver.

(f) Transmitter.

(g) Power supply.

(h) Power amplifier converter.

(i) Built-in test equipment (BITE).

(j) Monitor and alarm control panel.

(3) Restore radio A to normal and repeat the procedure for radio B.

51-5. DATA RECORDING AND ANALYSIS.

a. Record all test results on figure 51-2 (USACC Form 651-R).

b. Review the test results for completeness, accuracy, and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

c. If the radio fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

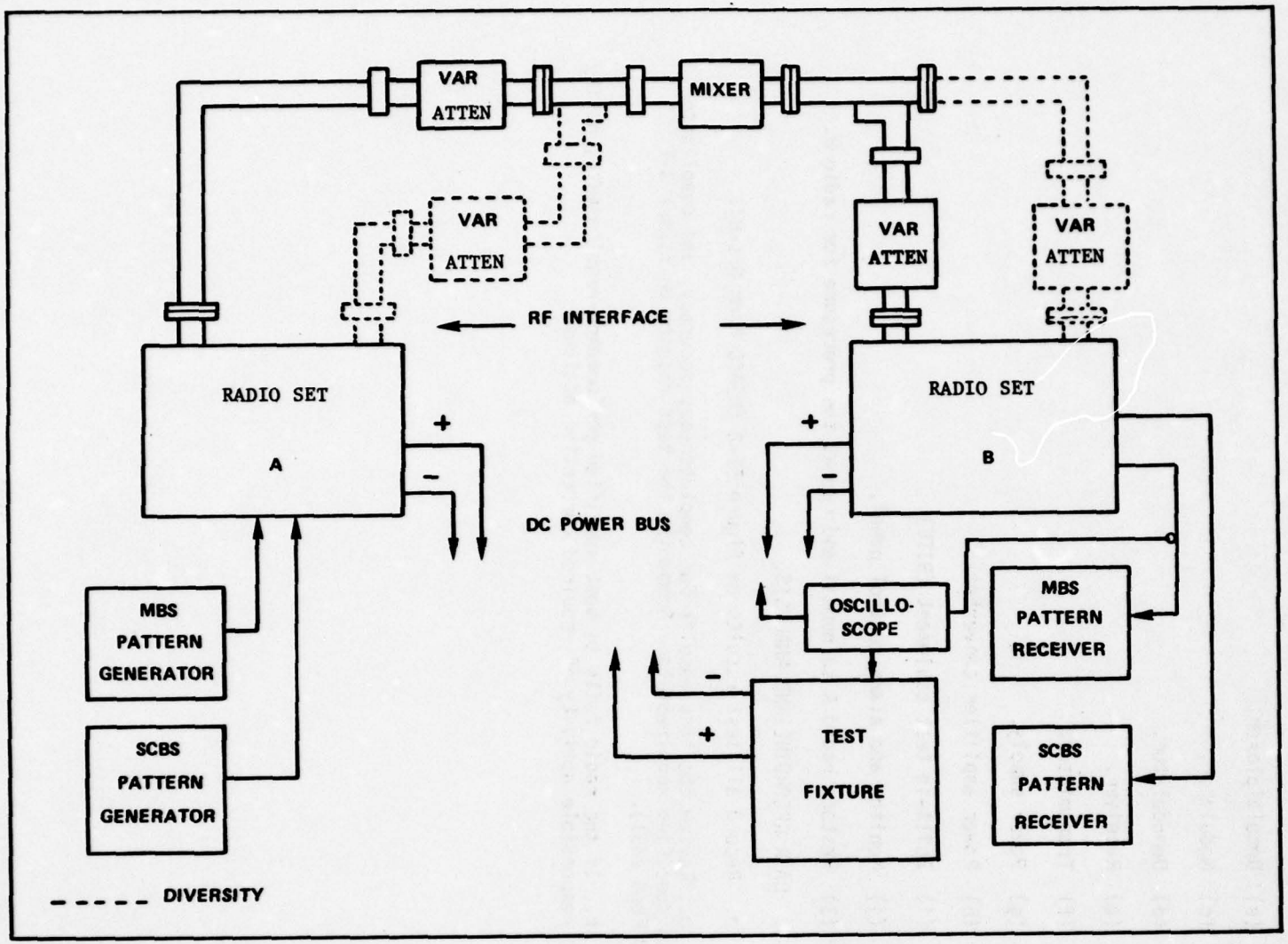


Figure 51-1. Power supply protection test setup.

POWER SUPPLY PROTECTION (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	DATA RATE mb/s	RSL (dBm) $5x10^{-2}$ ——— $5x10^{-9}$ ———

TEST CONDITION (FUSE REMOVED)	ALARM RCVD		SERVICE INTERRUPTION OR DEGRADATION	
	YES	NO	YES	NO
MULTIPLEX				
DEMULTIPLEX				
MODULATOR				
DEMODULATOR				
RECEIVER				
TRANSMITTER				
POWER SUPPLY				
POWER AMPLIFIER				
BITE				
MONITOR, CONTROL UNIT				

TRANSIENT DEGRADATION	SERVICE RESTORED IN 100 msec YES ☐ NO ☐
COMMENTS	

USACC FORM 651-R
1 MAY 79

Figure 51-2. Power supply protection data sheet.

CHAPTER 52

BIT ERROR RATE (AN/FRC-162)
(DT-249)

52-1. GENERAL.

a. The purpose of this test is to measure the BER of the AN/FRC-162.

b. This test can be performed in conjunction with DT-210; however, to cover all requirements of the specification, it has also been separately identified. For an equivalent test on the AN/FRC-( ), refer to DT-226.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel as directed.

52-2. SPECIFICATIONS.

a. The BER of the AN/FRC-162 in a back-to-back configuration shall not exceed $1x10^{-7}$ bits for an RSL of -71 dBm. This BER shall be achieved with a transmitter deviation of 3.14-MHz peak, baseband input and output levels of 1.0±0.25 VPP, pilot tone and modulated supervisory channel present, and the RSL measured at the RF interface point. (SCCC-73017)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

52-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Frequency counter.

c. Oscillator.

d. Oscilloscope.

e. Power meter with thermistor mount.

f. True RMS voltmeter.

g. Digital printer.

h. Turnaround mixer.

i. Digital multiplex.

j. Voltmeter.

k. Attenuators, adapters, connectors, and cables, as required.

52-4. TEST PROCEDURES.

a. Before performing this test, verify the transmitter-receiver alinement and perform DT-224 and DT-234, respectively.

b. Connect the test equipment as shown in figure 52-1 or 52-2. Allow approximately 30 minutes for warmup and stabilization.

c. With the oscilloscope, verify that the baseband input (J24) (filter in) and the receive abaseband output at J2 (receive switch on) is 1.0±0.25 VPP.

d. Connect a test oscillator to the transmit supervisor input (J15) and adjust the oscillator for -10 dBm at a frequency of 4 kHz. At the receive end, terminate the supervisory output (J14) into 75 ohms.

e. If using a digital multiplex to interface the test word generator into the radio as shown in figure 52-2, initially verify the multiplex performance by connecting the multiplex back-to-back and transmitting data for approximately 15 minutes while observing that there are no errors. Activate the error injection switch on the test word generator and note an error count of 47±1 errors per second.

f. If using a separate pattern generator and error detector as shown in figure 52-1, adjust the test set for 12.6 mb/s at a level of 1±0.25 VPP.

g. Adjust the RSL with the waveguide attenuators for a reading of -30 dBm as previously established during the receiver quieting or by using the typical AN/FRC-162 RSL versus AGC voltage curve shown in figure 52-3. A 1-dB change in RSL represents a 100 mV change in AGC voltage. Transmit data for 15 minutes to verify that the received data is error free. To verify that the counter is functioning properly, manually inject errors while observing that the counter registers the injected errors.

h. Reduce the RSL to -71 dBm with the waveguide attenuators and again transmit data for 15 minutes at 1-minute sample intervals unless otherwise directed. Record the total number of bits transmitted for each 1-minute interval, number of errors, and the average BER. Calculate the average BER using the following formula:

$$\text{BER} = \frac{\text{error count}}{(\text{sample period}) \times \text{data rate} \times 10^7}$$

i. Record all data on figure 52-4 (USACC Form 652-R).

j. Repeat the above procedures for other radios to be tested.

52-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for accuracy, completeness, and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specifications, notify the responsible activity of required corrective actions.

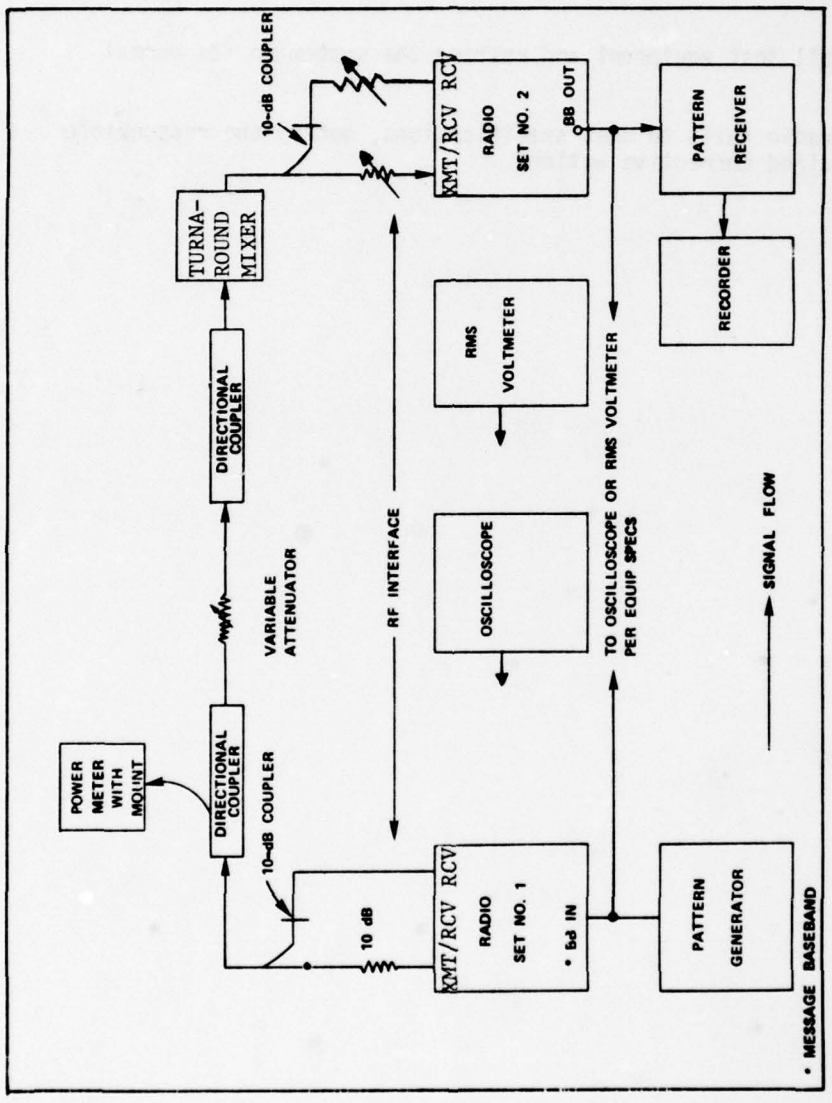


Figure 52-1. BER test setup using pattern generator and error detector (AN/FRC-162).

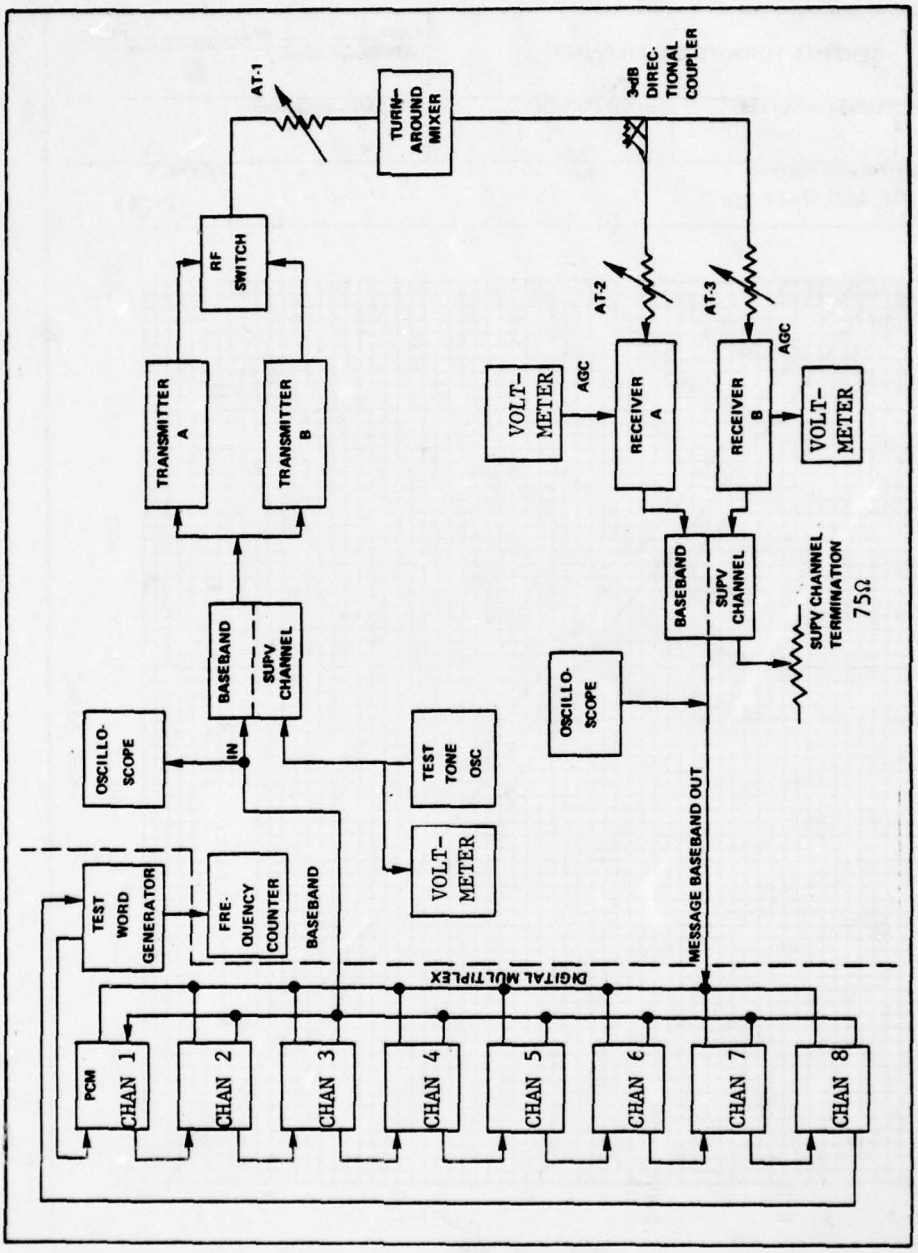


Figure 52-2. BER test setup using digital multipiex (AN/FRC-162).

GENERAL PURPOSE GRAPH PAPER

PAGE _____ OF _____ PAGES

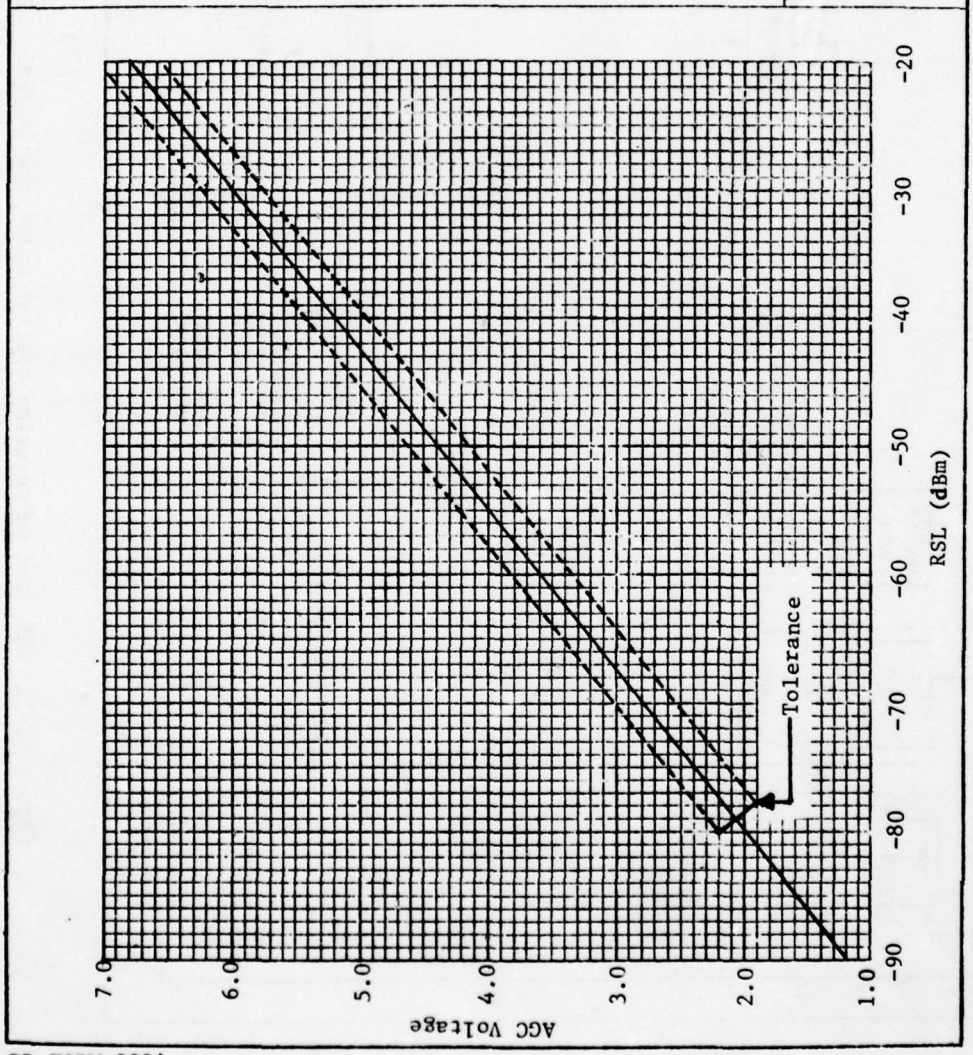
DATE (day, mo., year)

DATA SHEET

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE

TITLE OF PERFORMANCE PLOTTED: RSL vs AGC Voltage

TEST NO.: DT-249



DD FORM 2094

Figure 52-3. Typical RSL vs AGC voltage curve (AN/FRC-162).

BIT ERROR RATE (AN/FRC-162) (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YEAR)	
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER	
XMTR SER NO.	RCVR SER NO.	DATA RATE mb/s	PILOT LVL dBm	SUBCARRIER LVL dBm
XMT BB LVL VPP	RCV BB LVL VPP	XMT SUPV LVL dBm	RCV SUPV LVL dBm	XMT DEVN MHZ
SAMPLE NO.	SAMPLE PERIOD	BITS TRANSMITTED	NO. ERRORS	AVERAGE BIT ERROR RATE %
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
COMMENTS				

USACC FORM 652-R
1 MAY 79

Figure 52-4. BER (AN/FRC-162) data sheet.

CHAPTER 53

MBS AND SCBS INPUT/OUTPUT CABLE REQUIREMENTS (DT-250)

53-1. GENERAL.

a. The purpose of this test is to demonstrate the ability of MBS and SCBS to interface with long input/output cables.

b. This test is not applicable to the AN/FRC-162; however, it may be performed on this radio at the baseband and supervisory channel inputs/outputs as required.

c. This test may be performed on contractor EF&I systems to verify that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

d. Since this test primarily verifies a design feature of the radio, it would not normally be performed during onsite testing.

53-2. SPECIFICATIONS.

a. The MBS inputs/outputs (AN/FRC-( )) shall operate with any cable length (RG-108A/G or equivalent) up to and including 100 feet. The SCBS shall operate with any cable length up to and including 750 feet. (CCC-74049)

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

53-3. TEST EQUIPMENT REQUIRED.

a. MBS BER test set.

b. SCBS BER test set.

c. Oscilloscope.

d. Voltmeter.

e. Turnaround mixer.

f. Attenuators, adapters, and cables, as required.

53-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 53-1. Allow approximately 15 minutes for warmup and stabilization. Omit the turnaround mixer if the transmitter and receiver are tuned to the same frequency.

b. At the transmit and receive MBS input and output coaxial connectors, connect a 100-foot length of RG-108A/G cable. Connect the other end of the cable to a pattern generator or to a digital multiplexer/demultiplexer. If using a multiplexer/demultiplexer, connect the pattern generator/receiver to the channel input/output of the multiplexer/demultiplexer and loop the channels to provide the specified aggregate bit rate.

c. Connect a 750-foot length of RG-108A/G to the SCBS input/output connectors of the radio. Connect the other end to the pattern generator/receiver. Adjust the pattern generator/receiver for 192 kb/s, NRZ data.

NOTE: The attenuators shown in figure 53-1, connected to the MBS/SCBS, can be used to simulate the RG-108A/G cable loss at the specified data rate. If the attenuators are used, they should be adjusted to the equivalent loss at the specified data rate of that expected or measured on the cable lengths in paragraph 53-2.

d. Adjust AT-1 to provide a safe operating level into the turnaround mixer and adjust AT-2 for an RSL of -30 dBm. Use the results of DT-224 to ascertain the AGC voltage level corresponding to a -30 dBm.

e. Adjust the radio input/output levels, as required, to ensure that the levels are compatible with the external digital multiplexer/demultiplexer or BER test set.

f. At the transmit and receive ends, connect the radio for MBS-1 operation and transmit data on the MBS and SCBS for 15 minutes. Note that no degradation of the received data occurs. Reduce the RSL corresponding to a BER of $5x10^2$ and repeat the above procedures.

g. Connect the radio for MBS-2 operation and connect the input/output of the MBS-2 to the BER test set. Repeat subparagraph f, above, for MBS-2.

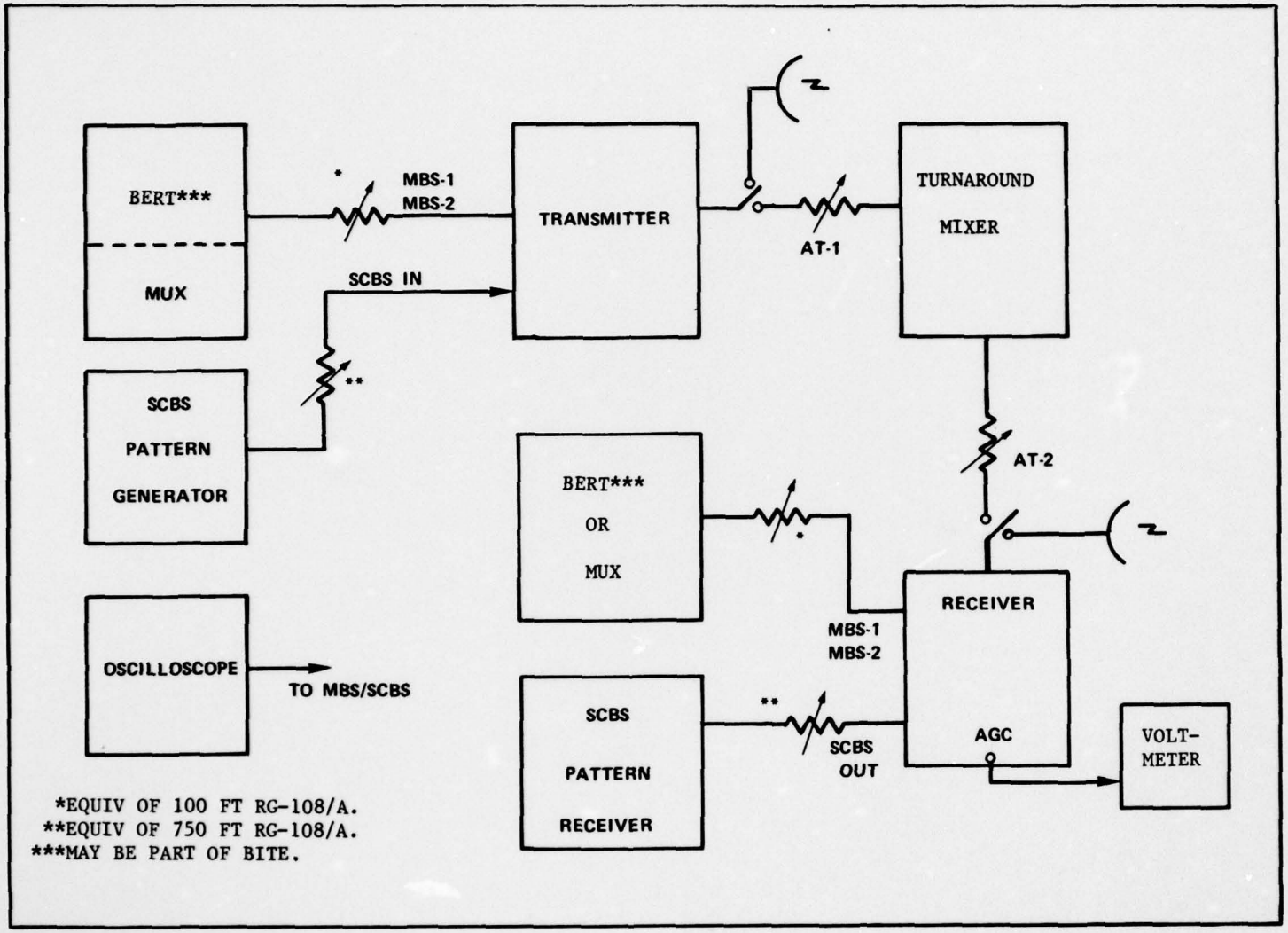
h. Record the test results on figure 3-7 (DD Form 2091).

53-5. DATA RECORDING AND ANALYSIS.

a. Review the test results and ensure that the radio meets specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.



CCP 702-11

Figure 53-1. Cable interface test setup (AN/FRC-( )).

CHAPTER 54

RADIO EMISSION PARAMETERS AND MBS RATES (DT-251)

54-1. GENERAL.

a. The purpose of this test is to demonstrate the requirements for changes in frequency, bit rates, level of performance, and transmitted bandwidths of the AN/FRC-( ).

b. This test is not applicable to the AN/FRC-162.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed; however, it primarily pertains to initial equipment acceptance at a contractor's facility.

54-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-( ): (CCC-74049)

(1) The radio shall operate at the frequencies, bit rates, and bandwidths contained in table 29-3. Changes in operating frequencies within the band, bit rates, level of performance, and transmitted bandwidths shall be accomplished by module or component exchange in 8 hours or less. The use of pretuned or prealined assemblies or components is permissible. Refer to table 29-2 for typical data rates.

(2) The radio shall operate in one of the following frequency bands:

(a) Band 1 - 4400 to 5000 MHz.

(b) Band 2 - 7125 to 8400 MHz.

(3) Requirements for all terminal configurations specified herein shall be met for any combination of transmitter and receiver frequencies that are integral multiples of 10 kHz except that transmitter-to-transmitter and receiver-to-receiver frequency separation for the frequency diversity terminal shall be at least 100 MHz, and transmitter-to-receiver frequency separation for all terminals shall be at least 80 MHz.

(4) The transmitter shall satisfy the transmitted bandwidth requirements for each data rate/bandwidth combination as contained in table 29-3. The

attenuation of the transmitted spectrum relative to the mean unmodulated power in a 4-kHz band shall not be less than that given by the following relationship.

$$A = 35 + 0.8\ (P - 50) + 10\ \log_{10} B$$

Where:

A = attenuation (in dB) below the mean output power level.

P = percent removed from the authorized center frequency relative to the authorized bandwidth.

B = authorized bandwidth in MHz.

In addition, these attenuation values shall govern for frequencies removed from the center frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth. Attenuation in these areas shall not be less than 50 dB and attenuation greater than 80 dB is not required.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

54-3. TEST EQUIPMENT REQUIRED. As specified in the individual tests listed in paragraph 54-4b, below.

54-4. TEST PROCEDURES.

a. Connect the radio for back-to-back operation as shown in figure 54-1 and allow approximately 30 minutes for warmup and stabilization. Omit the turnaround mixer if the transmitter and receiver are tuned to the same frequency.

b. Perform the following tests to establish a baseline of data on which to base the results of subsequent testing:

(1) RF interface (VSWR) (DT-207).

(2) Transmitter RF output power (DT-233).

(3) RF spectrum bandwidth (DT-222).

(4) Receiver spurious response and image rejection (DT-221).

(5) Receiver small signal performance, dynamic range, and BER performance floor (DT-226).

(6) Receive intermodulation (DT-227).

(7) Receiver and transmitter failure modes (DT-210).

c. Once the above tests have been performed and a baseline of data established for operating band 1 or 2, as applicable, at a frequency in the low end of the operating range, change the MBS to that shown in table 29-3. Repeat the above tests. Repeat the sequence for each of the data rates and bandwidths as shown in table 29-3.

d. Change the transmitter and receiver to a frequency at the high end of band 1 or 2, as applicable, ensuring that proper separation is maintained as outlined in paragraph 54-2, if testing a diversity terminal. Perform the tests outlined in 54-4b, above, at the data rates shown in table 29-3.

e. Repeat paragraphs 54-4 c and d, above, for performance levels I and II as shown in table 29-2.

f. Record the test results on the data sheets provided as part of the individual tests. Determine if the operating frequency, bandwidth, and bit rate of the radio could be changed in 8 hours or less without any performance degradation.

54-5. DATA RECORDING AND ANALYSIS.

a. Review the individual test results to ensure completeness and compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the radio to its normal configuration.

c. If degradation in performance is noted when changing the bit rate, bandwidth, or frequency of the radio, notify the responsible activity of required corrective actions.

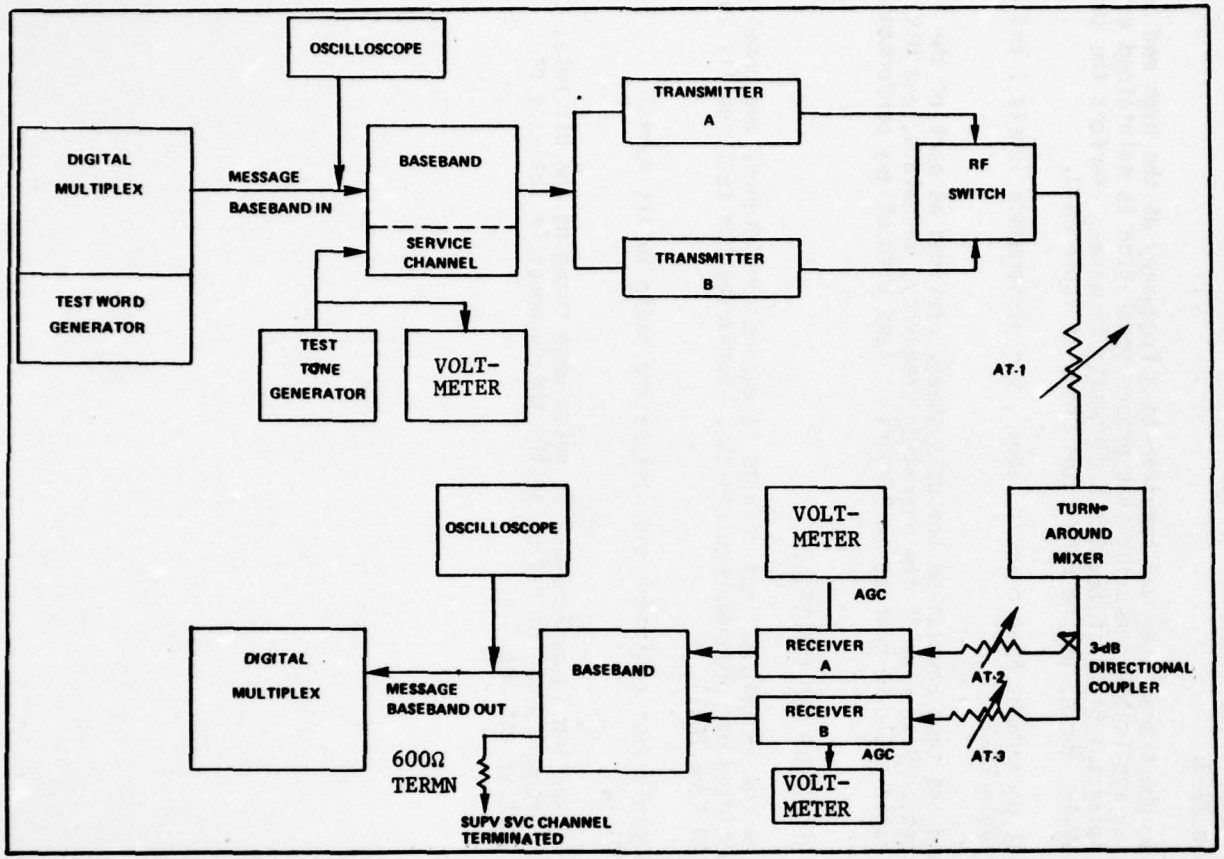


Figure 54-1. Back-to-back (AN/FRC-162) test setup.

CHAPTER 55

SCBS INTERFACE REQUIREMENTS (DT-252)

55-1. GENERAL.

a. The purpose of this test is to demonstrate that the BER of the SCBS is not degraded when connected to a TD-1192 multiplexer/demultiplexer.

b. This test is not applicable to the AN/FRC-162.

c. This test may be performed in conjunction with DT-211.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be performed by installer or quality assurance personnel during onsite test activities as directed; however, it is more applicable during initial equipment acceptance at a contractor's facility.

55-2. SPECIFICATIONS.

a. The SCBS shall provide interface interoperability among all radios procured in accordance with the standard. To this end, the composition and use of 192 kb/s PCM SCBS shall be specified. (MIL-STD-188-322)

b. When the SCBS of the radio (AN/FRC-( )) is connected to a TD-1192, the BER at the output of the TD-1192 50-kb/s data channel shall not be increased from that measured when the radio is configured back-to-back with an RSL corresponding to a BER of 5×10^{-9}. (CCC-74049)

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

55-3. TEST EQUIPMENT REQUIRED.

a. MBS BER test set.

b. SCBS BER test set.

c. TD-1192 multiplexer/demultiplexer.

d. TD-1193 multiplexer/demultiplexer.

e. Voltmeter.

f. Oscilloscope.

g. Mixer.

h. Adapters, attenuators, connectors, and cables, as required.

55-4. TEST PROCEDURES.

a. Connect the radio in a back-to-back loop as shown in figure 55-1 and allow approximately 30 minutes for warmup and stabilization.

b. Adjust AT-1 or AT-3 to provide a safe operating level into the turn-around mixer and adjust AT-2 or AT-4 for an RSL corresponding to a BER of $5x10^{-9}$. Refer to table 10-1.

c. Connect the pattern generator or digital multiplexer to the MBS-1 or MBS-2 and connect the radio accordingly. If using a pattern generator as the input signal to the transmitter, adjust the bit rate to correspond to the input data rate of the radio. Adjust the input MBS level for 1 VPP.

d. At the receive end, measure the MBS output level to ensure it is 1 VPP. Also configure the receiver and MBS pattern receiver or demultiplexer to correspond to the transmitted data rate.

e. Transmit and receive data on the MBS input/output for 15 minutes to ensure that the MBS is within the $5x10^{-9}$ BER requirement.

f. Connect a pattern receiver to the TD-1192 demultiplexer (AN/FCC-98) 50-kb/s data channel and again transmit and receive data on the MBS and SCBS while observing the receive 50-kb/s data channel output for errors. The performance level established in subparagraph e, above, should not be degraded with the TD-1192 connected to the SCBS input.

g. Record the test results on figure 3-7 (DD Form 2091).

h. Repeat the above procedure for other radios to be tested and at other data rates if required.

55-5. DATA RECORDING AND ANALYSIS.

a. As a minimum, record the following data on figure 3-7 (DD Form 2091).

(1) Serial number of equipment being tested.

(2) MBS input/oputput data rate.

(3) RSL for a BER of $5x10^{-9}$.

(4) Input and output voltage levels for the MBS and SCBS.

(5) Any 50-kb/s channel degradation noted as a result of the TD-1192 (AN/FCC-98) input/output at the SCBS.

b. Remove all test equipment and restore the system to its normal configuration.

c. If channel degradation is observed, notify the responsible activity of required corrective actions.

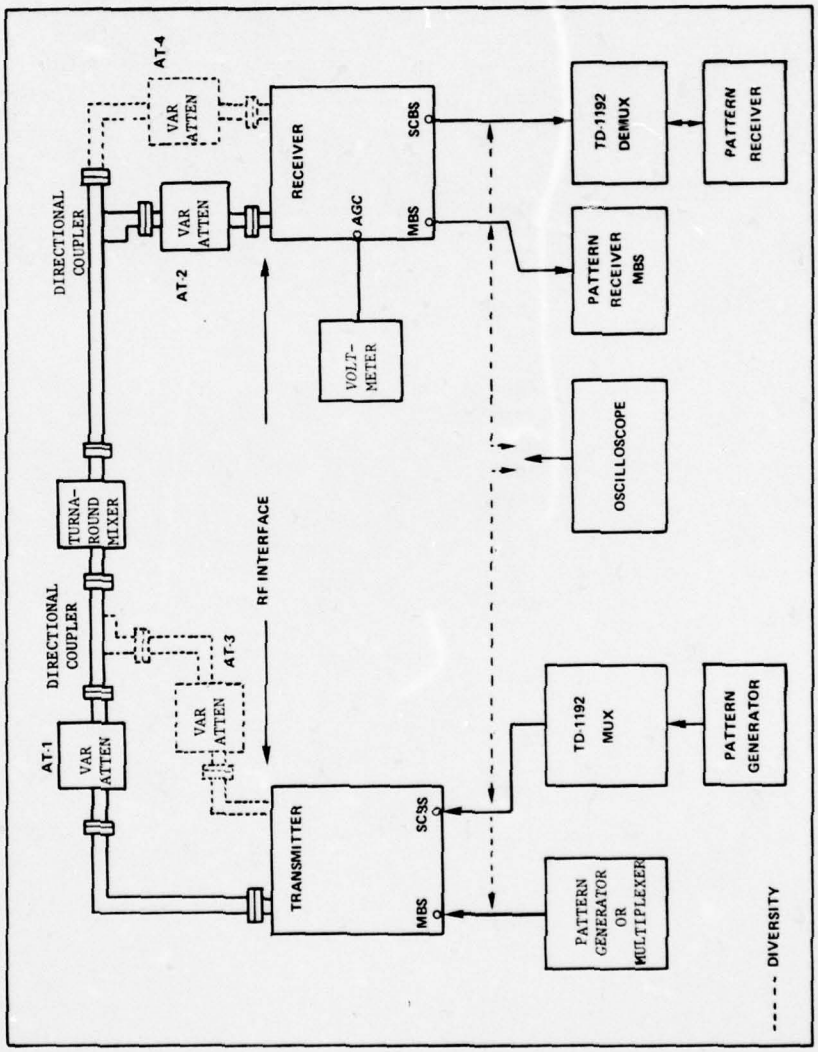


Figure 55-1. SCBS interface test setup.

CHAPTER 56

TRANSMIT TIMING OUTPUT (DT-253)

56-1. GENERAL.

a. The purpose of this test is to determine the performance characteristics of the AN/FRC-( ) transmitter timing output.

b. This test is not applicable to the AN/FRC-162.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. However, it is more applicable at a contractor's facility during initial acceptance testing of the radio set to determine that the product meets specified requirements. Therefore, to duplicate initial inplant test data during follow-on testing when the radio is placed in a field environment is not feasible unless the same environmental conditions can be duplicated.

56-2. SPECIFICATIONS.

a. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) *Initial accuracy.* One hour after the radio is energized and at room ambient temperature (25±5 degrees Centigrade), the frequency of the timing output shall be within $\pm 3 \times 10^{6}$ of the nominal values contained in table 15-2.

(2) *Environmental stability.* The frequency of the timing output (table 15-2) of the internal TDM when subjected to the full operating temperature range as contained in table 39-1 shall not deviate more than $\pm 10 \times 10^{6}$ from that obtained at 25±5 degrees Centigrade.

(3) *Long-term stability.* The frequency of the timing output (table 15-2) of the internal TDM shall not deviate more than 1×10^{6} per month when repeated readings are taken at any single stable temperature (within ±2 degrees Centigrade) within the range of operating temperatures as contained in table 39-1.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

56-3. TEST EQUIPMENT REQUIRED.

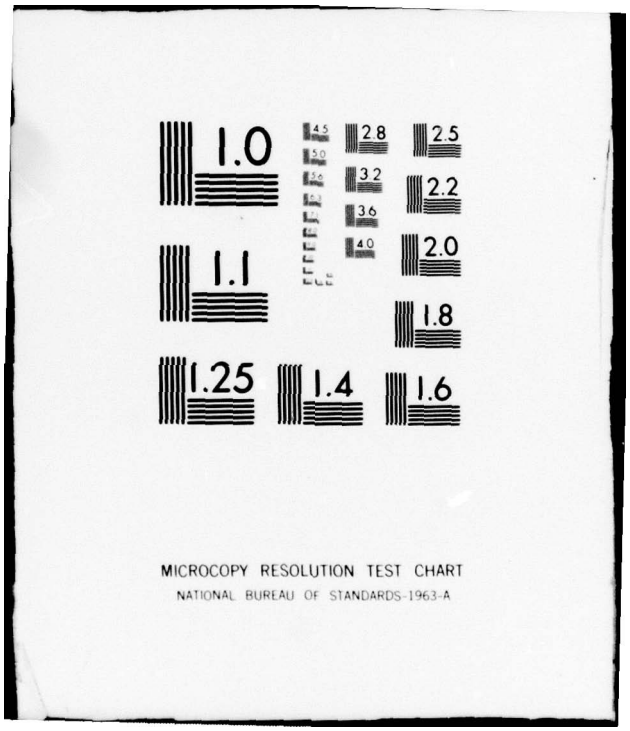
a. Signal generator.

b. Frequency counter.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

6 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

c. Digital printer.

d. Digital-to-analog converters.

e. Temperature and humidity sensors.

f. Environmental test chamber.

g. Recorder.

h. Programmable calculator.

i. DC power supply

j. Digital voltmeter

k. Connectors, cables, adapters, and wires, as required.

56-4. TEST PROCEDURES.

a. General.

(1) The four basic techniques for measuring the frequency accuracy and stability of transmitter output timing as used in this procedure are:

(a) Taking spot measurements with a frequency counter and manually recording the readings after which the individual readings are averaged to arrive at a median value.

(b) Recording the readings with a digital printer connected to the frequency counter and manually averaging the individual readings to arrive at a median value.

(c) Recording and storing the readings in a programmable calculator with the calculator automatically providing the median values of all test samples.

(d) Converting the frequency counter digital output to an analog or DC signal and recording any variations from the assigned frequency over a specified timeframe.

(2) The method used will depend on the availability of test equipment and the requirements of the team chief. Any of the above techniques may be used and will depend on the degree of accuracy required from the test results.

(3) Connect the test equipment as shown in figure 56-1 and allow approximately 30 minutes for warmup and stabilization. If this test is being performed under controlled environmental conditions, calibrate the temperature and humidity recording device according to the manufacturer's instructions to cover the operating ranges as shown in table 39-1.

(4) Initially connect the generator output to the frequency counter and adjust the generator frequency to correspond to the applicable timing frequency of the radio. Refer to table 15-2 for the specified timing output frequencies of the radio internal TDM.

(5) Adjust the output level of the generator to correspond to the radio timing output levels and adjust the frequency counter for a stable reading of the generator frequency. If using a stripchart, recorder, or programmable calculator, calibrate these devices by using the generator and frequency counter to establish the center frequency and expected variations of the timing signals.

NOTE: Ensure that the test equipment does not load down the timing output of the circuit under test.

(6) Repeat these procedures for other radios to be tested.

b. Initial Accuracy.

(1) If the test is being performed under controlled environmental conditions, adjust the chamber temperature for 25±5 degrees Centigrade at a relative humidity of 50 percent.

(2) After the correct temperature and humidity conditions have been established, turn on the radio and allow approximately 30 minutes for warmup and stabilization. Measure the timing outputs and record the values on figure 56-2 (USACC Form 653-R).

c. Environmental Stability.

(1) Connect the test equipment as shown in figure 56-1 or 56-3, and for this part of the test, the timing outputs should be recorded with a digital printer, stripchart recorder, or by a programmable calculator. Refer to figure 56-4 for a typical military standard profile.

(2) Adjust the environmental chamber temperature for 0 degree Centigrade at a relative humidity of 0 percent. Allow sufficient time for the chamber temperature and humidity to stabilize as noted on the recording device.

(3) Record the timing output frequency for a period of 1 hour or as directed. If using a digital printer or calculator, adjust the frequency counter to provide for a 10-second printout of the measured frequency. A longer or shorter sample period may be used, if required.

(4) Determine the average measured frequency from the recorded data and compute the frequency accuracy using the following formula:

$$A = \frac{F_c - F_{md}}{F_c} \times 100 \text{ percent}$$

Where:

A = timing output frequency accuracy

F_c = specified timing output frequency

F_{md} = measured average timing output frequency

(5) Record the timing accuracy on the data sheet.

(6) Change the environmental chamber temperature to 49 degrees Centigrade at a relative humidity of 95 percent.

(7) Repeat paragraphs 56-4c (3), (4), and (5), above.

(8) Reduce the chamber humidity to 50 percent or less and allow the equipment to dry out.

(9) If using a stripchart recorder to record the timing output frequency accuracy and stability, reduce the recording to an average value and compute the frequency accuracy as outlined in paragraph 56-4c(4), above.

d. Long-Term Stability.

(1) Adjust the environmental chamber for a temperature of 0 degree Centigrade at a relative humidity of 0 percent.

(2) If spot measurements of the timing output frequency are taken, they should be made approximately every 15 minutes throughout the test period. Therefore, a long-term recording, as provided by the digital printer, stripchart recorder, or calculator, would be more appropriate than a spot measurement.

(3) Record the timing output frequency for a period of 8 hours and then change the chamber temperature to 49 degrees Centigrade with a relative humidity of 95 percent. Record the results for 8 hours. Note, on the recordings, each temperature and humidity change as well as the date and time that the change was made.

(4) Continue recording the timing output frequency for 30 days while periodically changing the temperature and humidity for those operating levels shown in table 39-1. If an altitude requirement is also a part of the test, periodically adjust the chamber pressure to simulate the altitude requirements of table 39-1. This change in pressure should be made in time correlation with the temperature and humidity variations.

(5) If spot measurements are made for 30 days, average the test results and determine the frequency accuracy as outlined in paragraph 56-4c(4), above.

(6) Record the test results on the data sheet.

e. Alternate Method. This method can be used for both short-term sampling and long-term recordings as shown in figure 56-3. This method uses an RF counter whose output is fed into a programmable calculator. The temperature and humidity control of the environmental chamber can also be controlled and adjusted by the calculator. The calculator may also be preprogramed to print out selected information on demand or continuously such as number of samples, average frequency, timing frequency, accuracy, low and high excursions, and stability. This method is much more accurate than the other methods since a larger number of samples can be taken over a shorter period of time. Further, reducing and analyzing the test results is accomplished automatically.

56-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the results for compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specifications, notify the responsible activity of required corrective actions.

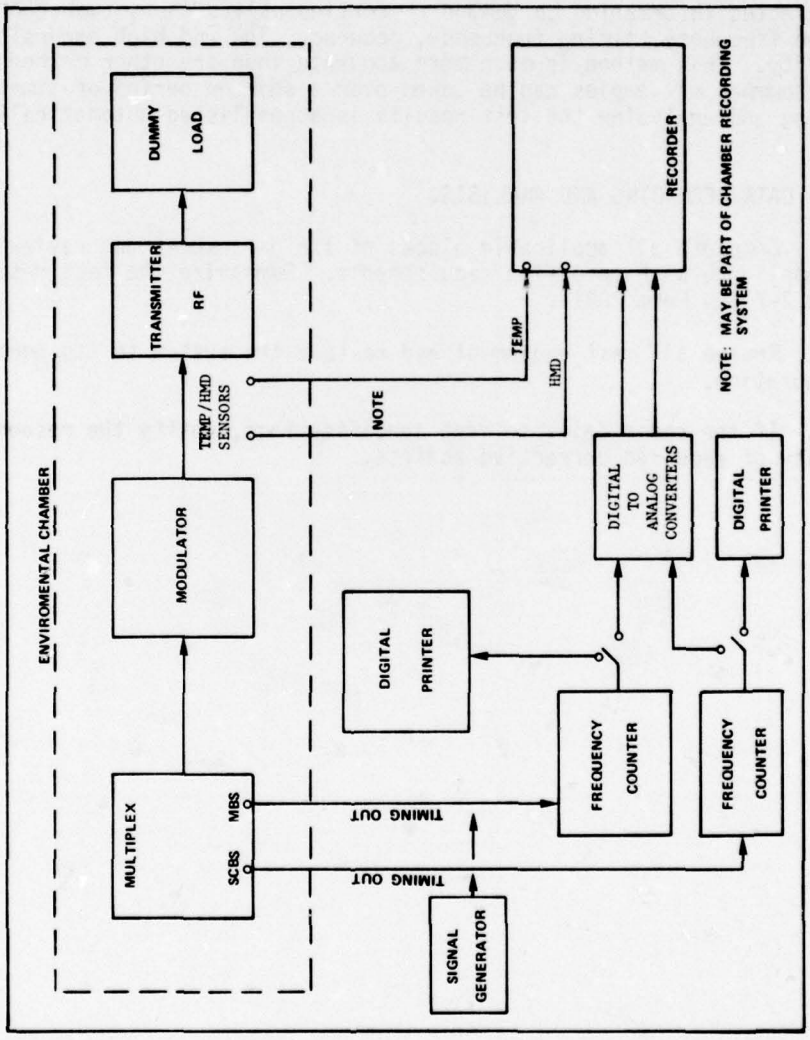


Figure 56-1. Transmitter timing output test setup.

TRANSMITTER TIMING OUTPUT ACCURACY AND STABILITY (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	DATA RATE mb/s	TIMING FREQUENCY MHz	TEST METHOD

TEST PERFORMED

INITIAL ACCURACY ☐ ENVIROMENTAL STABILITY ☐ LONG-TERM STABILITY ☐

TEMP (°C)	HUMIDITY (%)	NO. OF SAMPLES	SAMPLE AVERAGE	TEMP (°C)	HUMIDITY (%)	NO. OF SAMPLES	SAMPLE AVERAGE

FREQUENCY ACCURACY AND STABILITY: %

COMMENTS

USACC FORM 653-R
1 MAY 79

Figure 56-2. Transmitter timing output accuracy and stability data sheet.

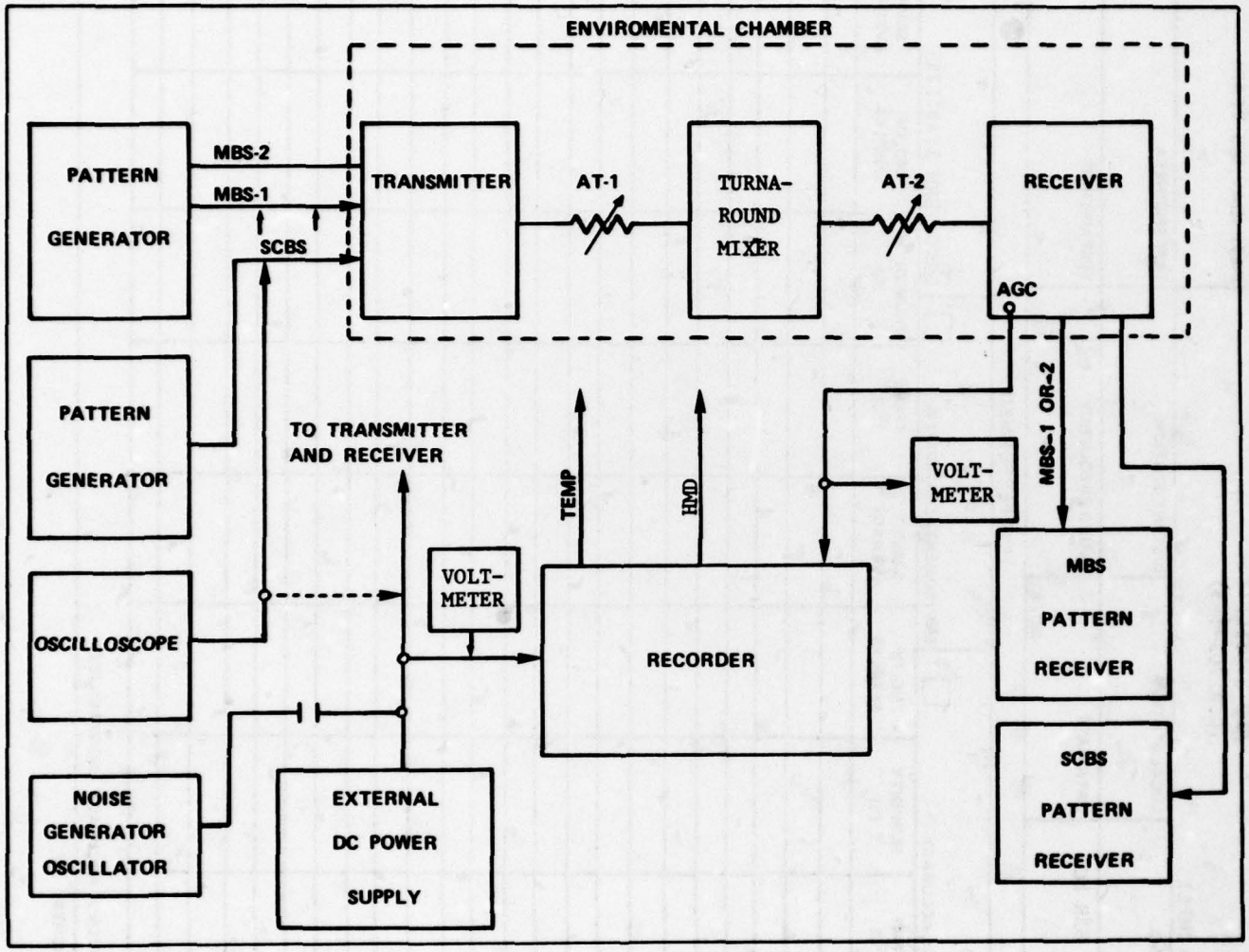
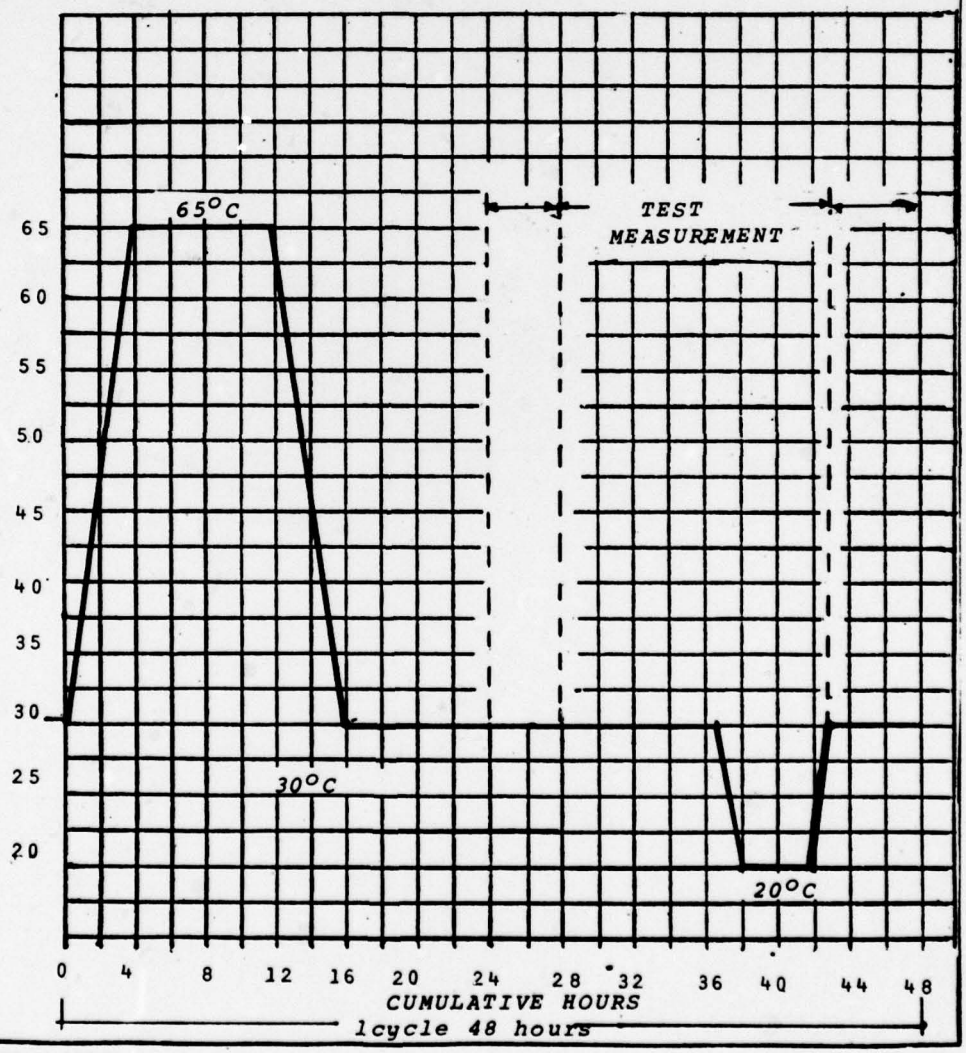


Figure 56-3. Transmitter frequency accuracy test setup.

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3) DATA SHEET			PAGE _____ OF _____ PAGES
			DATE (DAY, MO., YEAR)
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE
TITLE OF PERFORMANCE PLOTTED AND DETAILS *Example of a temperature Humidity cycle MIL-STD-810C, 507.1-5*			TEST NO. DT-253



DD FORM 2094

Figure 56-4. Temperature and humidity profile (MIL-STD-810C).

CHAPTER 57

LOCKUP AND INTERFACE PROTECTION (RADIO) (DT-254)

57-1. GENERAL.

a. The purpose of this test is to demonstrate that the built-in lockup and interface circuits provide the input/output protection as specified in paragraph 57-2, below.

b. This test is not applicable to the AN/FRC-162.

c. Normally, this test would be performed at a contractor's facility during initial acceptance testing and before equipment acceptance by the government. Therefore, it should not be repeated during onsite test activities of government furnished, contractor, or military installed systems.

57-2. SPECIFICATIONS.

a. Interface circuit protection shall be provided so that any driver or terminator will not be damaged by the following: (MIL-STD-188-100)

(1) Voltage magnitudes of 25 volts on the terminator leads.

(2) Shorting of the input or output leads to ground or to each other.

(3) Crossing of the leads with any other physical leads of the interface.

(4) Opening of either or both of the input or output leads.

b. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) *Lockup protection.* The operation of the radio shall be such that when a 25-volt pulse as described below is applied simultaneously to any combination of input/output leads, no logic lockup shall occur that results in service outage or degraded performance requiring manual intervention to restore service. The rise time of the voltage pulse shall be 0.5 volt/nsec with a duration of 1 μsec between the 50-percent amplitude points.

(2) *Interface protection.* Interface protection shall be provided as specified in subparagraph a, above.

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

57-3. TEST EQUIPMENT REQUIRED.

a. MBS BER test set or digital multiplex.

b. SCBS BER test set.

c. Oscilloscope.

d. Voltmeter.

e. Pulse generator.

f. Adapters, connectors, cables, and attenuators, as required.

57-4. TEST PROCEDURES.

a. Connect the radio for back-to-back operation as shown in figure 53-1. Connect the test equipment as shown in the figure and allow approximately 30 minutes for warmup and stabilization.

b. Adjust AT-1 to provide a safe operating level into the turnaround mixer and adjust AT-2 for an RSL corresponding to a BER of $5x10^{-9}$. Select the RSL to be used based on the performance level and data rate of the radio (table 10-1). Omit the turnaround mixer if the transmitter and receiver are tuned to the same operating frequency.

c. Measure and adjust the output level of the transmit pattern generators, the receive MBS, and the SCBS. Adjust the levels for 1 VPP.

d. Transmit data for 15 minutes on the MBS-1 and SCBS while observing that the received error rate is equal to or better than a BER of $5x10^{-9}$. In turn, switch the radio for MBS-2 and parallel operation and repeat the above sequence. This will establish that the radio meets the BER performance and provide a baseline for comparing subsequent test results.

e. Apply a 25-volt pulse as specified in paragraph 57-2(1), above, to each of the input/output leads of the radio separately while observing that the manual intervention is not required to restore service (fig. 57-1; USACC Form 654-R). Record the results on the data sheet.

NOTE: Ensure that the pulse generator produces only one output pulse for each time the manual pulse injection switch is activated.

f. Separately, short each of the input/output leads as shown in figure 57-2 to ground. Remove the short and transmit data as outlined in paragraph 57-4d, above, to determine that the established BER has not changed.

g. Separately, short each input/output lead and again transmit data to verify that the established BER did not change.

h. Cross the input/output leads of the radio interface such as the MBS leads to the timing leads and MBS to the SCBS. Remove the crosses and transmit data to verify that the established BER did not change as a result of crossing of the leads.

i. Momentarily open the MBS-1 and MBS-2 input/output leads, and after the leads have been properly restored, transmit data to verify that the $5x10^{-9}$ BER is not affected.

j. Repeat the above procedure for other radios to be tested.

57-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and verify that the test results are complete and accurate. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified requirements, notify the responsible activity of required corrective actions.

LOCKUP AND INTERFACE PROTECTION (RADIO) (CCR 702-1-3)			PAGE OF PAGES
DATA SHEET			DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
XMTR SER NO.	RCVR SER NO.	ASGD FREQ MHz	PERFORMANCE LEVEL I ☐ II ☐
RSL (dBm)	BIT RATE MHz	REF BER	

INPUT/OUTPUT LEVELS (VPP)					
RECEIVE			TRANSMIT		
MBS-1	MBS-2	SCBS	MBS-1	MBS-2	SCBS

TEST CONDITION	TEST RESULTS PASSED	TEST RESULTS FAILED	REMARKS
25 VOLTS APPLIED TO EACH INPUT			
25 VOLTS APPLIED TO EACH OUTPUT			
EACH INPUT SHORTED TO GROUND			
EACH OUTPUT SHORTED TO GROUND			
INPUTS SHORTED TOGETHER			
OUTPUTS SHORTED TOGETHER			
INPUTS/OUTPUTS CROSSED			
INPUT/OUTPUT MBS/SCBS OPEN			

COMMENTS

USACC FORM 654-R
1 MAY 79

Figure 57-1. Lockup and interface protection (radio) data sheet.

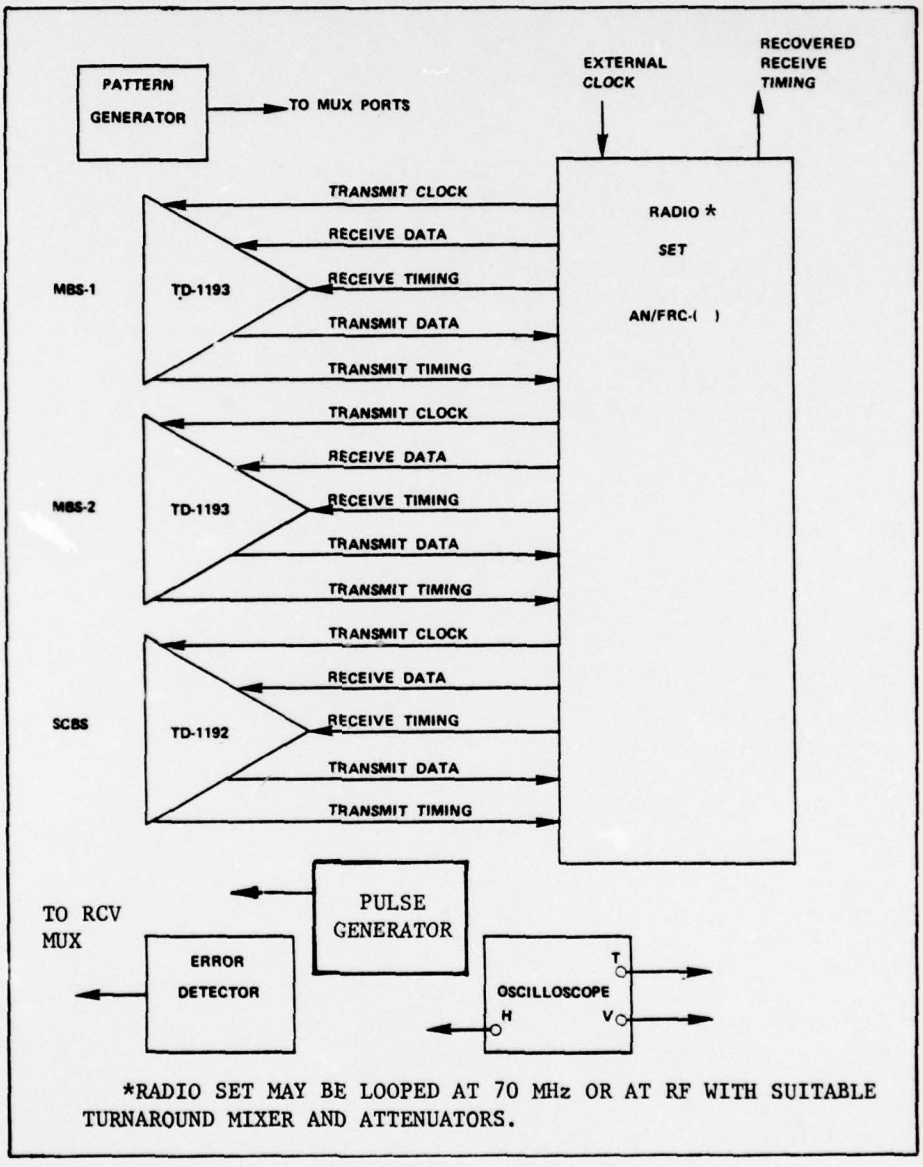


Figure 57-2. AN/FRC-( ) inputs/outputs test setup.

CHAPTER 58

SIGNAL PERFORMANCE MONITOR (DT-255)

58-1. GENERAL.

a. The purpose of this test is to determine the characteristics of the signal performance monitor functions of the AN/FRC-( ).

b. This test is not applicable to the AN/FRC-162 as initially installed in Europe.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be performed by installer or quality assurance personnel during onsite test activities; however, it is more applicable during initial equipment acceptance.

58-2. SPECIFICATIONS.

a. The radio shall include circuitry to monitor critical functions and provide separate signals directly related to monitored qualities. Terminals shall provide external access to monitor signals. The monitor signals shall be of such type and quality as necessary to provide adequate assurance of required subsystem performance. The quantities monitored shall include the following: (MIL-STD-188-322)

(1) MBS's at receiver output ports.

(2) RSL at demodulator input.

(3) Transmit RF interface output power.

(4) Demodulator MBS eye pattern quality before regeneration.

b. The following criteria applies to the AN/FRC-( ). (CCC-74049)

(1) *Received signal level.* A signal shall be provided which is linearly proportional to the RSL in dBm. The monitor shall have a linear (±3 dB) range from 5 dB below to 50 dB above the RSL of 5×10^{-2} for specified bit rates as computed from table 29-2. The sensitivity shall be at least 0.1 volt per dB change in RSL.

(2) *Frame error rate.* The framing bits in the radio shall be monitored for errors. A pulse shall be provided at a connector on the radio when each error occurs. The source impedance shall be 75 ohms ±10 percent, unbalanced. The signal shall be 1 volt ±10 percent square pulses with nominal pulse duration equal to the data unit interval of the aggregate bit rate.

(3) *Transmitter RF output power.* The transmit power level shall be displayed on a front panel meter.

(4) *Signal quality monitor.* The radio shall monitor degradation of the received demodulated signal (eye pattern) before data recovery and shall have an output voltage that is monotonically related to the S/N ratio of the demodulated signal. This relationship shall hold for a peak signal RMS noise ratio of 40 dB to that degradation corresponding to a BER of $1x10^{-2}$. In addition to the signal quality monitor output, buffered outputs shall be provided for each of the individual patterns.

c. The radio shall operate as specified in the standard engineering plan or contract specifications.

58-3. TEST EQUIPMENT REQUIRED.

a. RF sweep generator.

b. Power meter.

c. Frequency counter.

d. AC/DC voltmeter.

e. RMS voltmeter.

f. Oscillator.

g. BER test set.

h. Impedance bridge.

i. RF voltmeter.

j. Oscilloscope.

k. Turnaround mixer.

58-4. TEST PROCEDURES.

a. Received Signal Level.

(1) Connect the equipment as shown in figure 58-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Connect the generator to the power meter and adjust the generator to the center frequency of the receiver.

(3) Adjust the generator internal attenuators to cover a range of at least 5 dB below to 50 dB above the RSL corresponding to a BER of $5x10^{-2}$ as obtained from table 29-2. Verify that the generator output is linear and accurate over the required output range. If there is a disparity between the power meter reading and the indicated generator output, calibrate the generator power level at each power setting.

(4) Connect the generator to the receiver RF interface point and set the generator output level to at least 50 dB above the RSL corresponding to a BER of $5x10^{-2}$ as calculated from table 29-2.

(5) On the radio monitor and alarm panel, adjust the internal meter to read the RSL. Record the panel meter reading, the receiver input RF level, and the AGC voltage on figure 58-2 (USACC Form 655-5).

(6) Reduce the generator output in 1-dB steps while recording the panel meter reading and the AGC voltage level for each RF input level to the receiver. Continue reducing the receiver RF input level until the input signal level is at least 5 dB below the value calculated from table 29-2. Record the RF input level, panel meter reading, and AGC voltage for each change in the receiver RF input.

(7) Plot the test results on figure 3-4 (DD Form 2094) and determine if the panel meter is linear (±3 dB) over the required RF input level. Also verify that a 1-dB change in the receiver input level, results in at least a 0.1-volt change in the AGC voltage.

(8) If required, repeat the above procedure for each date rate for which the radio is designed.

b. Transmit Power Level.

(1) Connect the test equipment as shown in figure 58-3 and adjust the transmitter power level for the output level specified in table 36-1.

(2) Record the power meter level and the monitor alarm panel meter reading on figure 58-2 (USACC Form 655-R).

(3) Adjust the power level control on the transmitter to reduce the power by 3 dB and note the panel meter reading on the data sheet. Reduce the output level an additional 3 dB and check that the panel meter corresponds to the 6-dB reduction in output power.

c. Frame Error Rate/Test Point Impedance.

(1) Connect the test equipment as shown in figures 58-4 and 58-5, with the impedance bridge connected to the external frame error connector of the radio. Disconnect or remove any signal output voltage appearing at the connector output to preclude interferring with the test results.

NOTE: In general, for bridge measurements the test lead would be an open circuit at point A of figure 58-4a, while the bridge zero balance is being accomplished. Due to the wide variation of available impedance bridges, test personnel should consult the equipment instruction manual before making impedance measurements.

(2) Calibrate the bridge by connecting a 78 ohm ±1 percent precision resistor across the bridge input terminals as shown in figure 58-4 and zero balance the bridge. Once the bridge has been zero balanced, remove the precision resistor and connect the bridge input to the frame output connector of the radio as shown in figure 58-4b.

(3) Set the impedance bridge decades to a rough balance. Using the oscillator, adjust the frequency to the midrange of the highest data rate for which the radio is configured. Adjust the bridge until a zero balance is obtained and record this value on figure 58-2 (USACC Form 655-R). An alternate method would be to calibrate an oscillator output into a 78-ohm precision resistor, remove the resistor, and connect the oscillator output to the frame output connector of the radio. Read the voltage drop across the connector input. The impedance can then be calculated from this voltage drop.

(4) Adjust the RSL to correspond to a BER of 5×10^{-9} and connect the oscilloscope (channel A) to the external frame error connector. Connect channel B to the MBS output and adjust to display one complete data interval. Set the oscilloscope for external trigger and connect the trigger input to the up/down frame error module. Simulate a frame error and note that each time an error is injected a 1-volt square wave appears at the frame error connector with a nominal pulse duration equal to the data unit interval of the aggregate bit rate. Record the results on figure 58-2 (USACC Form 655-R).

d. Signal Quality Monitor.

(1) Connect the test equipment as shown in figure 58-5. Adjust the audio oscillator to 1020 Hz at a level of -10 dBm0. Adjust the RSL with the waveguide attenuator to correspond to a BER of 1×10^{-2}.

(2) Slowly increase the RSL until it corresponds to a BER of 5×10^{-9} while measuring the SNR at the monitor test point and the RMS voltage of the demodulated 1020-Hz test tone. The SNR can be determined from:

$$SNR = 10 \log_{10} \frac{P_{signal}}{P_{noise}}, \text{ (in dB)}$$

(3) Determine the peak signal to RMS noise ratio at an RSL corresponding to a BER of 1×10^{-2} and record this value on figure 58-2 (USACC Form 655-R). Determine whether the eye pattern output voltage correlates to the S/N ratio peak RMS signal value up to and including an SNR of 40 dB. Record the results on figure 58-2 (USACC Form 655-R).

58-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for accuracy and completeness. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio under test fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

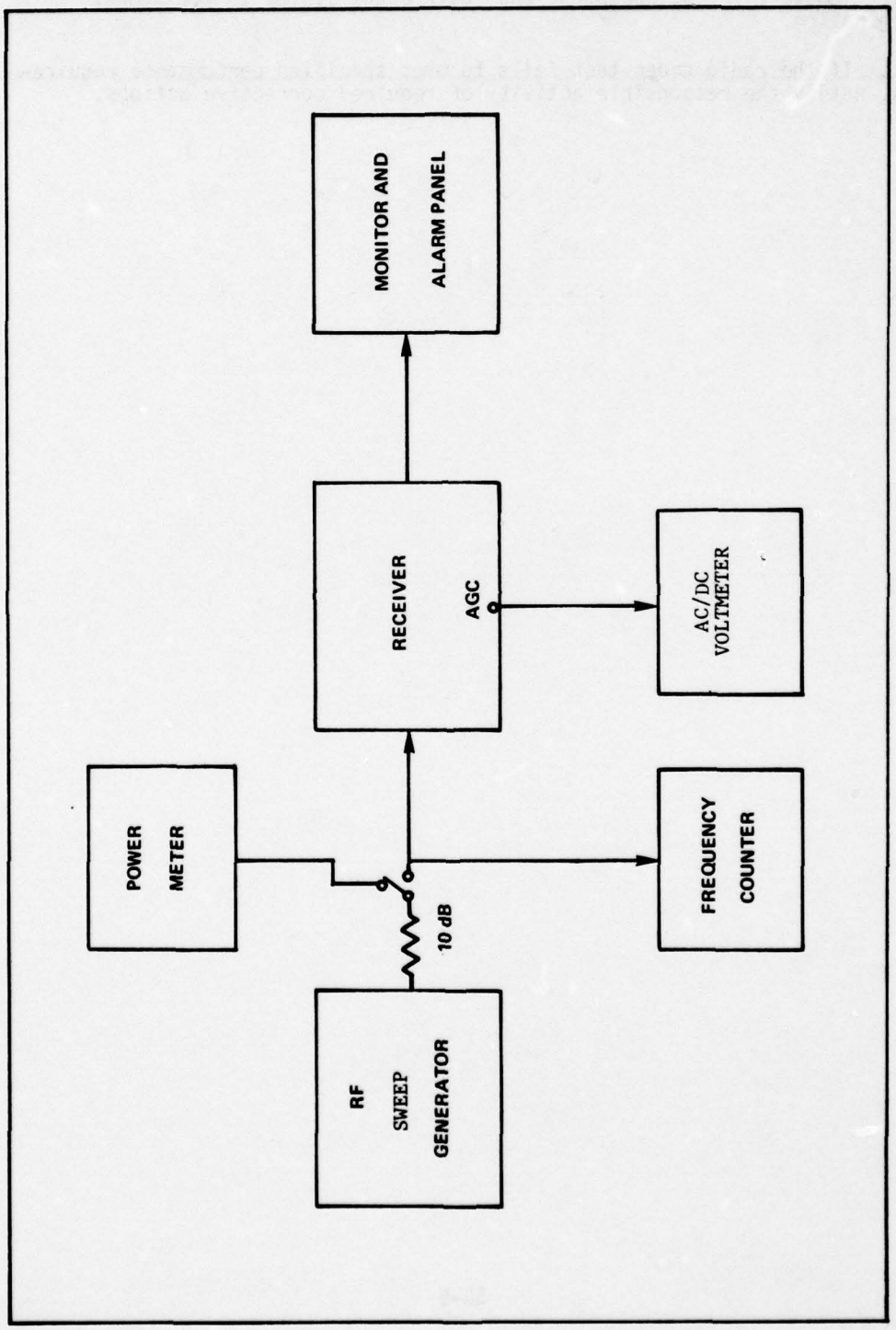


Figure 58-1. Signal performance monitor (RSL) test setup.

SIGNAL PERFORMANCE MONITOR
(CCR 702-1-3)

PAGE ____ OF ____ PAGES

DATE (DAY, MO, YEAR)

DATA SHEET

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

XMTR SER NO.	RCVR SER NO.	BANDWIDTH MHz	DATA RATE mb/s

ASQD FREQ MHz	RSL FOR BER 5×10^{-6} dBm	RSL FOR BER 5×10^{-2} dBm	PERFORMANCE LEVEL I ☐ II ☐

RECEIVED SIGNAL LEVEL

RSL (dBm)	AGC (VDC)	PANEL METER READING	RSL (dBm)	AGC (VDC)	PANEL METER READING

FRAME ERROR

CONN IMPEDANCE	VPP	ERRORS RCVD

TRANSMIT POWER

OUTPUT (dBm)	PANEL METER READING	OUTPUT (dBm)	PANEL METER READING

SNR FOR: BER = 5×10^{-6} _____ dB BER 5×10^{-2} _____ dB BER 1×10^{-2} _____ dB

USACC FORM 655-R
1 MAY 79

Figure 58-2. Signal performance monitor data sheet.

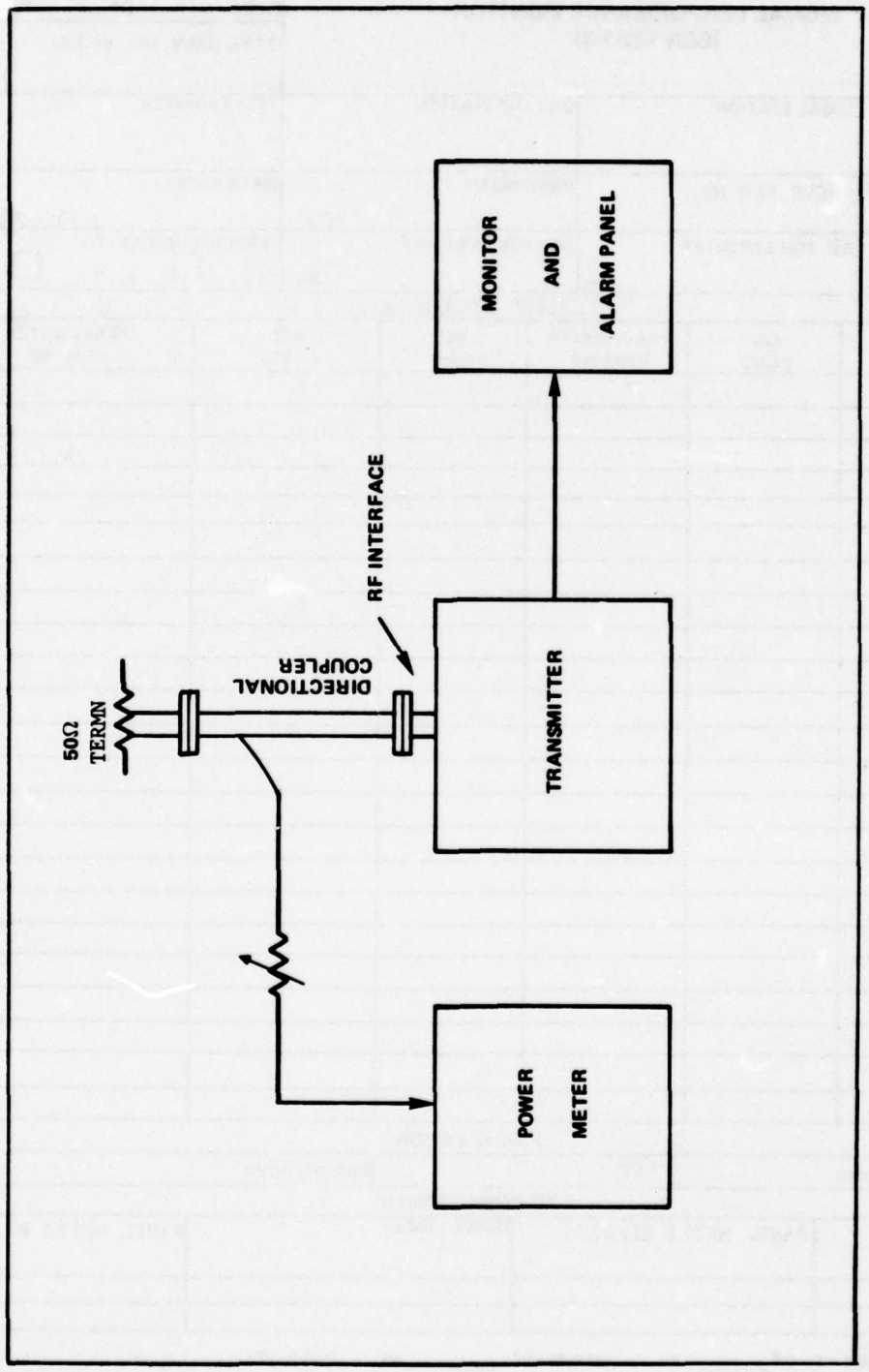


Figure 58-3. Transmitter RF power output test setup.

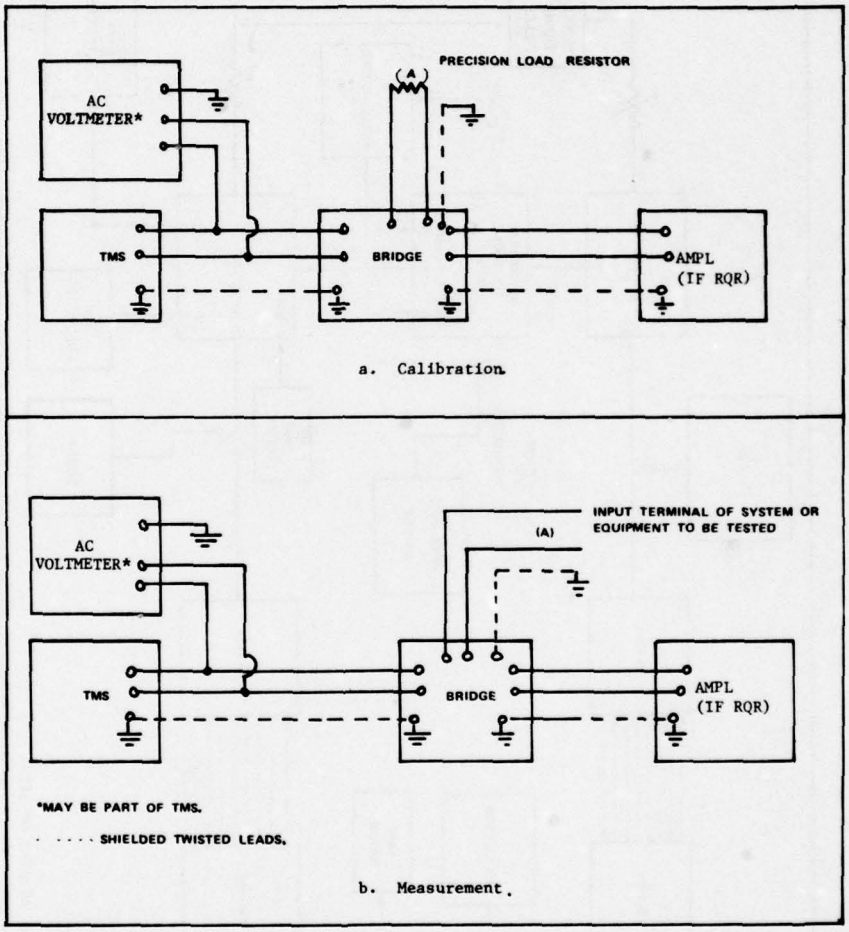


Figure 58-4. Test point impedance (bridge method) test setup.

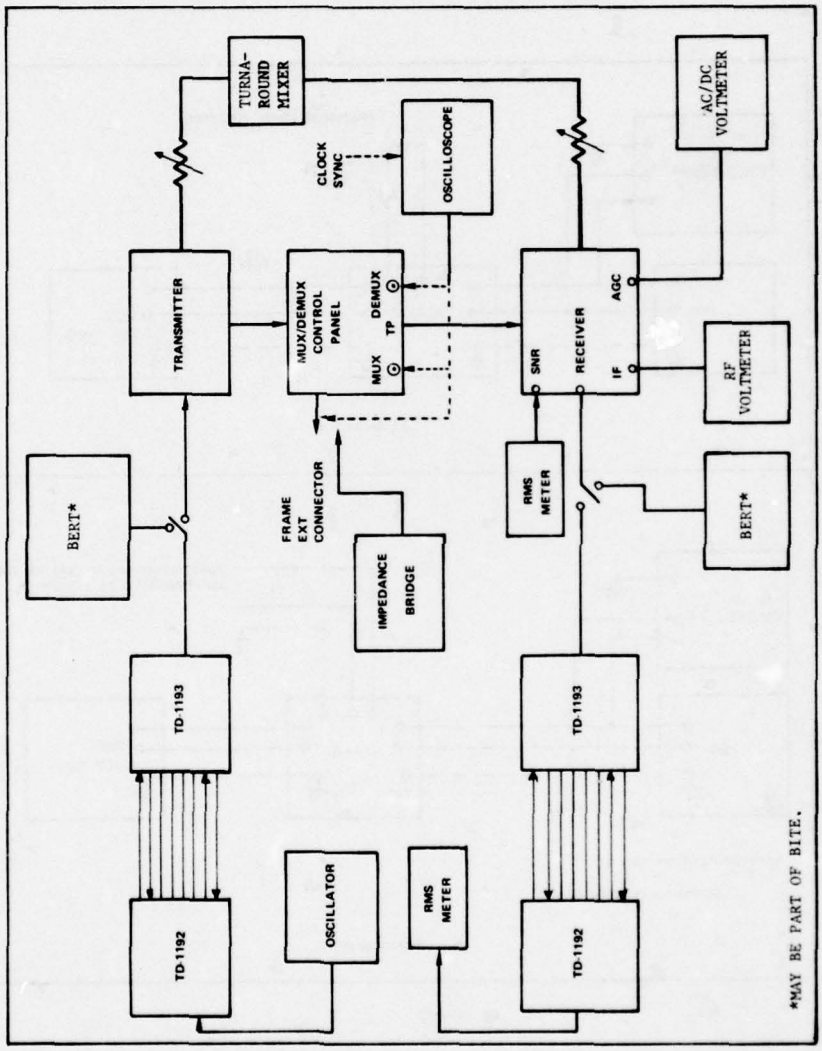


Figure 58-5. Frame error/impedance test setup.

CHAPTER 59

RF TRANSMITTER AFC CHARACTERISTICS (DT-256)

59-1. GENERAL.

a. The purpose of this test is to verify the proper operation of the AFC reference unit and the AFC unit.

b. The frequency modulators (solid state oscillators) of the AN/FRC-162/165 radios used in the AN/FRC-162 and VICOM 4000-2 system should not be detuned and retuned. Power, frequency, and linearity are all interdependent and, in accordance with the pertinent equipment manual, should be adjusted only if out of specification.

c. This test is similar to DT-240 except that these procedures are tailored to the AN/FRC-162 and VICOM 4000-2 system.

59-2. SPECIFICATIONS. Refer to DT-240.

59-3. TEST EQUIPMENT REQUIRED.

a. Microwave link analyzers.

b. True RMS voltmeter.

c. Frequency counter.

d. Coaxial test coupler.

59-4. TEST PROCEDURES.

a. Refer to figure 59-1. Perform subparagraph b, below, if there is an indication of frequency error on the transmitter subsystem control unit (18P2A-MW) meter when switched to transmit frequency. The meter should read 0±3 scale divisions with the AFC on and stabilized. If not, the problem could be that either the AFC reference unit (23K5A-MW) is off frequency or the 70-MHz AFC unit (23Q3B-MW) discriminator zero is in error.

b. Connect J3 of the AFC reference unit to a frequency counter. The frequency should read $F_0 \pm 50$ Hz (F_0 is the center frequency marked on the label attached to the unit). If the frequency is in error, adjust the C5 (frequency trim) control of the AFC reference unit to obtain the proper frequency.

c. Set the controls of the microwave link analyzer as follows:

(1) Sweep to off.

(2) Deviation to 35 kHz.

(3) Baseband frequency to off.

(4) Baseband input to internal.

(5) Sweep source to internal IF.

(6) Blanking to on.

d. Set the microwave link analyzer transmitter switch to 70-MHz crystal.

e. Disconnect the cable from J2 of the AFC reference unit. Connect the microwave link analyzer auxiliary output to this cable through a 30-dB attenuator. This will provide a -20 dBm signal to the AFC unit input J2 (transmitter 70 MHz in).

f. At the control unit (18P2A-MW), set the selector switch to transmit frequency and the AFC switch to off.

g. At the AFC unit, adjust the discriminator zero control R83 for a live-zero indication of the control unit meter. This will calibrate the AFC unit for proper discriminator response.

h. Connect a dBm meter such as the HP 3400A to the J25 transmit sensor jack of the coaxial connector panel, terminated in 75 ohms. This requires removing the 75-ohm termination which is normally connected to J25.

i. Remove the microwave link analyzer auxiliary output from the cable of subparagraph e, above. Connect the microwave link analyzer transmitter IF output, with the microwave link analyzer IF output attenuator set to provide a -20 dBm signal, to the cable. Vary the microwave link analyzer transmitter IF control around 70 MHz to obtain a live-zero indication on the control unit meter.

j. Set the microwave link analyzer baseband frequency to 555 kHz (also set to 555 kHz on the microwave link analyzer receiver).

k. Adjust the baseband level control R72 of the AFC unit for an indication of -40 dBm (-49 dBm on a 600-ohm meter). This will calibrate the transmit sensor jack for a -40 dBm test tone level (TLP) when the required deviation is applied to the transmitter.

l. Disconnect the test equipment and turn the control unit AFC switch on. Allow 2 minutes for the frequency to stabilize. The control unit meter should indicate 0±3 scale divisions. After subparagraphs b through k, above, have been performed, if there is still a faulty indication, then the actual transmit 2-GHz oscillator could be off frequency. Refer to DT-236 or to paragraphs 5-18 e and f of the AN/FRC-162 technical manual for further instructions.

59-5. DATA RECORDING AND ANALYSIS.

a. Record the results and any pertinent comments on figure 3-7 (DD Form 2091). Review the test results for completeness, accuracy, and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the radio fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

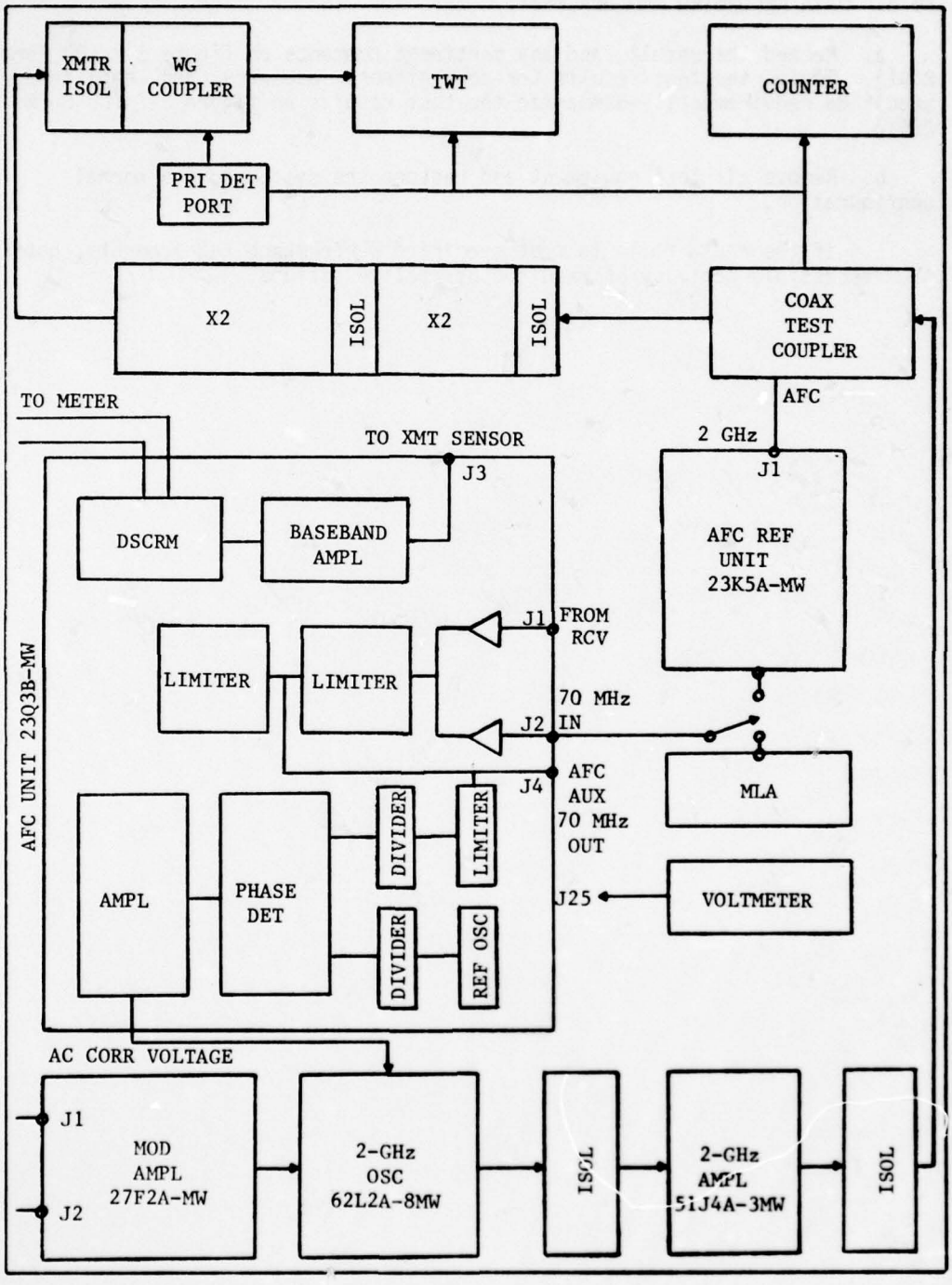


Figure 59-1. RF transmitter AFC test setup.

CHAPTER 60

TRANSMITTER MODULATOR FREQUENCY DEVIATION AND LINEARITY (DT-257)

60-1. GENERAL.

a. The purpose of this test is to check the linearity and the limits of linearity of the transmitter modulator peak frequency deviation (ΔF) over the operating range of the modulating signal RMS voltage levels.

b. The transmitter modulator frequency deviation and linearity can be determined by measuring the peak frequency deviation (ΔF) at the transmitter IF or RF signals. In order to obtain the RF carrier signal deviation, the measured deviation must be multiplied by a factor K where K is the frequency multiplication which the signal undergoes between the measuring point and the final RF signal output. However, in systems where the modulated IF is heterodyned to the RF carrier frequency, the actual frequency deviation is not altered and the peak deviation of the RF carrier signal is identical to the peak deviation of the IF signal.

c. Digital radios will normally differ from analog radios in that preemphasis is not required. As a result, the linearity curves should have approximately the same slope for all values of frequency versus modulating level. In addition, the baseband of the digital radios will probably extend higher in frequency than the analog radios used in military systems. The linearity and deviation should be checked as a minimum at three frequencies within the baseband to ensure that the system is operating properly.

d. In many cases, the proper level into the transmit baseband is specified in terms of VPP which must be read on an oscilloscope. . The manufacturer's manual should be consulted to determine the proper deviation setting prior to initiating the test. A sine wave read on a true RMS meter or an average responding meter with an RMS scale will be the same. The peak-to-peak value will be 2.8 times the value read on the meter.

e. This test is similar to DT-234 except that this procedure is based on the AN/FRC-162 type radios. Either procedure may be used during onsite test activities.

60-2. SPECIFICATIONS. Refer to DT-234.

60-3. TEST EQUIPMENT REQUIRED.

a. Microwave link analyzer.

b. IF/baseband transmitter HP 3710A.

c. Plug-in HP 3716A.

d. IF/baseband receiver HP 3702B.

e. Plug-in HP 3605.

f. Down converter HP 3730A.

g. Plug-in HP 3738A.

60-4. TEST PROCEDURES. Repeat the procedures for each transmitter at both ends of the link.

a. Modulator Amplifier Linearity and Level Adjustments. Perform microwave link analyzer back-to-back checks to ensure proper operation (fig. 60-1 and 60-2).

(1) Set the control as follows:

(a) Baseband plus sweep vernier to calibrate.

(b) Sweep calibration to counterclockwise.

(c) Sweep to off.

(d) Sweep width to 12 MHz.

(e) Baseband frequency to 555 kHz.

(f) Baseband input to external 75 ohms.

(g) Sweep source to external baseband plus sweep.

(h) Blanking to on.

(i) Y1 display to baseband.

(j) Y2 display to delay.

(k) Markers to ±5 MHz.

(2) Set the baseband power on the transmitter to provide an output of -40 dBm. Connect the baseband plus sweep vernier to modulator input A or B (J45/J46) of the radio.

(3) At the coaxial connector panel, remove the cable at transmitter 2 and terminate it in 75 ohms (cable and J2).

(4) On the modulator amplifier unit (27F2A-MW), turn resistor R20 fully clockwise.

(5) Set the receiver baseband power attenuator for -44 dBm. Connect the baseband input to the modulator amplifier output test point (J3).

(6) Adjust the modulator amplifier gain adjust (R37) for a 0-dBm0 reading on the IF/baseband level meter.

(7) Reset the receiver baseband power attenuator for -47 dBm. Adjust R20 on the radio for a 0-dBm0 reading on the IF/baseband level meter. The modulator amplifier gain should now be properly adjusted.

(8) Connect the transmitter IF output to the receiver IF input to provide frequency markers. Set the Y1 display to IF and adjust the IF attenuators to obtain an on-scale reading on the IF/baseband level meter. Ensure that the AFC lock lamp is illuminated and that the uncalibrated lamp is extinguished.

(9) Adjust the microwave link analyzer controls as follows:

(a) Y1 display to baseband.

(b) Sweep to internal.

(c) Baseband output power to -28 dBm.

(10) Connect the baseband plus sweep to a 75-ohm terminated meter and set a composite level of -12 dBm by adjusting the sweep calibration control. Connect the baseband plus sweep to modulator input A or B (J45/J46) of the radio.

(11) Calibrate the Y1 baseband linearity trace for 1 percent per division and the Y2 delay trace for 1 nsec per division. The microwave link analyzer is now set up to display the linearity and delay of the modulator amplifier over a 10-MHz bandwidth (markers should be set to ±5 MHz).

(12) If necessary, adjust the tilt control (R40) and the linearity control (C10) on the modulator amplifier to optimize the performance. It should be possible to obtain better than 0.5 percent nonlinearity.

(13) If R40 had to be adjusted, repeat subparagraphs (1) through (12), above, and recheck the R37 and R20 settings to verify proper adjustment.

b. *2-GHz Oscillator Deviation and Linearity.* Perform a microwave link analyzer transmitter alinement procedure and linearity check (figs. 60-3 and 60-4).

(1) Set the microwave link analyzer controls as follows:

(a) Sweep calibration to fully counterclockwise.

(b) Baseband plus sweep vernier to calibrate.

(c) Sweep source to internal IF.

(d) Sweep to off.

(e) Sweep width to 12 MHz.

(f) Baseband frequency to 92 kHz.

(g) Baseband input to internal.

(h) Blanking to on.

(i) Y1 display to IF.

(j) Y2 display to spectrum.

(2) Set the baseband output power to -27 dBm and adjust the vernier control to obtain -26.94 dBm (-35.94 on a 600-ohm meter terminated in 75 ohms).

(3) Connect the baseband plus sweep output to modulator input A or B (J45/J46) of the radio. Connect the receiver IF input to the AFC unit test point J4 (23Q3B-MW) via a wideband amplifier. Adjust the amplifier gain to provide a 20- to 40-dB input to the microwave link analyzer. The required gain will depend on the drive requirements of the microwave link analyzer input. Set the receiver IF attenuator to obtain an on-scale reading on the IF/baseband level meter.

(4) Adjust the receiver spectrum width control counterclockwise to obtain a wide spectral trace to observe 1st carrier dropout. The display should be close to 1st carrier dropout.

(5) Fine tune the transmitter modulator amplifier (27F2A-MW) control R37 for 1st carrier dropout. If the display in subparagraph (4), above, is not close to 1st carrier dropout, adjust the 2-GHz oscillator modulation probe (linearizer slug nut) for approximately 1st carrier dropout. Fine tune R37 of the modulator amplifier for 1st carrier dropout.

(6) Remove the transmitter baseband plus sweep output from the modulator input (J45/J46) and connect it to the transmitter 2 in-jack of the modulator amplifier.

(7) Adjust the transmitter 2 gain control R2 of the modulator amplifier for 1st carrier output as observed on the microwave link analyzer display.

(8) Remove the baseband plus sweep output from transmitter 2 of the modulator amplifier.

(9) Set the baseband frequency to 277 kHz and the baseband plus sweep output to -17.4 dBm (-26.4 dBm on a 600-ohm meter terminated in 75 ohms). This can be accomplished by setting the baseband power output to -17 dbm and adjusting the vernier output control.

(10) Connect the baseband plus sweep to modulator input A or B (J45/J46). The display should be close to 1st carrier dropout.

(11) Repeat subparagraphs (9) and (10), above, with the baseband frequency set to 555 kHz and the baseband plus sweep power set to -11.38 dBm. Observe for 1st carrier dropout.

(12) Set the baseband output power to -28 dBm and the vernier control to calibrate. Set the sweep to internal, the Y1 display to baseband, the Y2 to delay, and the markers to ±1.25 MHz.

(13) Adjust the sweep calibration control to obtain a baseband plus sweep output level of -12 dBm (-21 dBm on a 600-ohm meter terminated into 75 ohms). This will cause the transmitter to deviate by 10 MHz at an RF of 8 GHz, but the 2-GHz oscillator will deviate by only 2.5 MHz. The microwave link analyzer will display 2.5-MHz bandwidth with the markers set to ±1.25 MHz.

(14) Connect the baseband plus sweep to modulator input A or B (J45/J46). Adjust the baseband input attenuator to obtain an on-scale reading on the IF/baseband level meter.

(15) Turn the blanking off and adjust the X-phase-shift control to superimpose the forward and return traces. Turn the blanking on.

(16) Calibrate the Y1 baseband linearity trace for 1 percent per division on the microwave link analyzer graticule. Calibrate the Y2 delay trace for 1 nsec per division. The microwave link analyzer is now set to display the linearity and delay of the 2-GHz oscillator (with the modulator amplifier which has already been optimized) over the 2.5-MHz bandwidth (10 MHz at RF).

(17) If necessary, adjust the linear tilt adjust control of the 2-GHz oscillator for best linearity response. The linearizer slug nut should not be turned. Since these adjustments can affect the frequency of the 2-GHz oscillator, recheck the frequency and correct it, if necessary. The linearity should be within 1 percent.

c. Baseband-to-RF Linearity and Delay. Perform a final check of the transmitter linearity (fig. 60-5).

(1) For the AN/FRC-162 radio, connect the RF input of the down converter to the RF power detector port coupler. Tune the down converter to the transmit frequency to provide a 70-MHz output.

(2) For the AN/FRC-165 radio, connect the RF input of the down converter to the RF test port (J107) of the transmitter via a 10- to 20-dB RF attenuator. Tune the down converter to the transmit frequency to provide a 70-MHz output.

(3) Set the microwave link analyzer controls as follows:

(a) Baseband plus sweep vernier to calibrate.

(b) Sweep calibration to counterclockwise.

(c) Sweep to internal.

(d) Sweep width to 10 MHz.

(e) Baseband frequency to 555 kHz.

(f) Baseband input to internal.

(g) Sweep source to internal IF.

(h) Blanking to on.

(i) Y1 display to IF.

(j) Y2 display to delay.

(k) Markers to ±5 MHz.

(4) Connect the baseband plus sweep to a 75-ohm terminated meter and adjust the sweep calibration control to obtain a -12 dBm composite level. Connect the baseband plus sweep to modulator input A or B (J45/J46) of the transmitter.

(5) Connect the down converter 70-MHz output to the receiver IF input. Adjust the IF attenuator of the receiver to obtain an on-scale reading on the IF/baseband level meter. Ensure that the AFC lock lamp is illuminated and the IF uncalibrated lamp is extinguished.

(6) Turn the blanking off. Adjust the X-phase-shift control to superimpose the forward and return traces. Turn the blanking on. This will cause the transmittter to deviate by 10 MHz and will set up the microwave link analyzer to reflect ±5 MHz around the center frequency (transmit frequency down converter to 70 MHz).

(7) Set the Y1 display to baseband and adjust the baseband input attenuator to obtain an on-scale reading on the IF/baseband level meter.

(8) Calibrate the Y1 trace to display 1 percent per division. Calibrate the Y2 trace to display 1 nsec per division. The microwave link analyzer will now display baseband-to-RF total transmitter linearity and delay.

(9) Photograph the display and mount the photographs on figure 5-2 (DD Form 2093). Enter the linearity and delay readings on the data sheet. For an example of the microwave link analyzer display of linearity and delay, see figure 21-2.

60-5. DATA RECORDING AND ANALYSIS.

a. Ensure that all pertinent information is entered on the data sheet. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

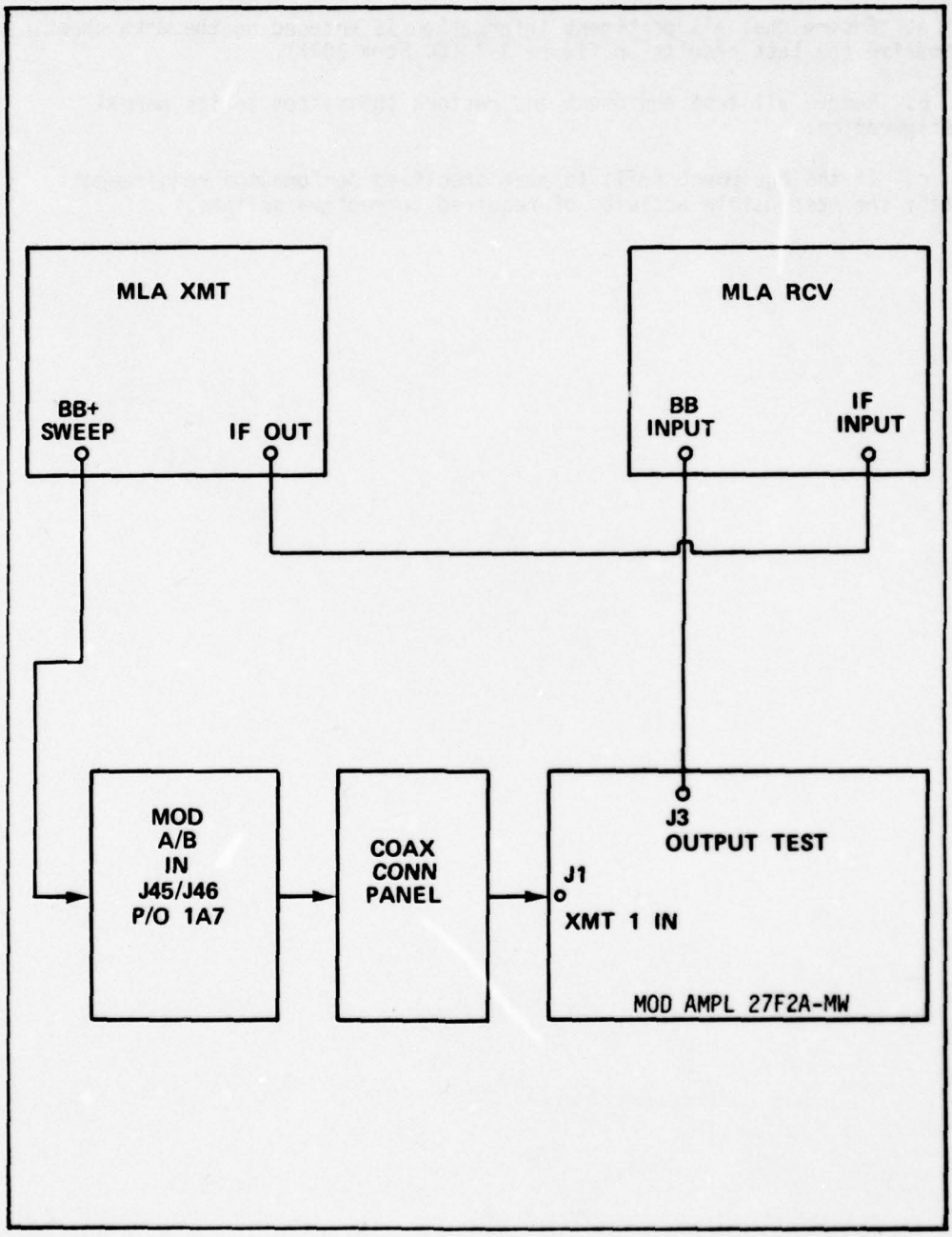


Figure 60-1. Modulator amplifier linearity and level adjustment test setup.

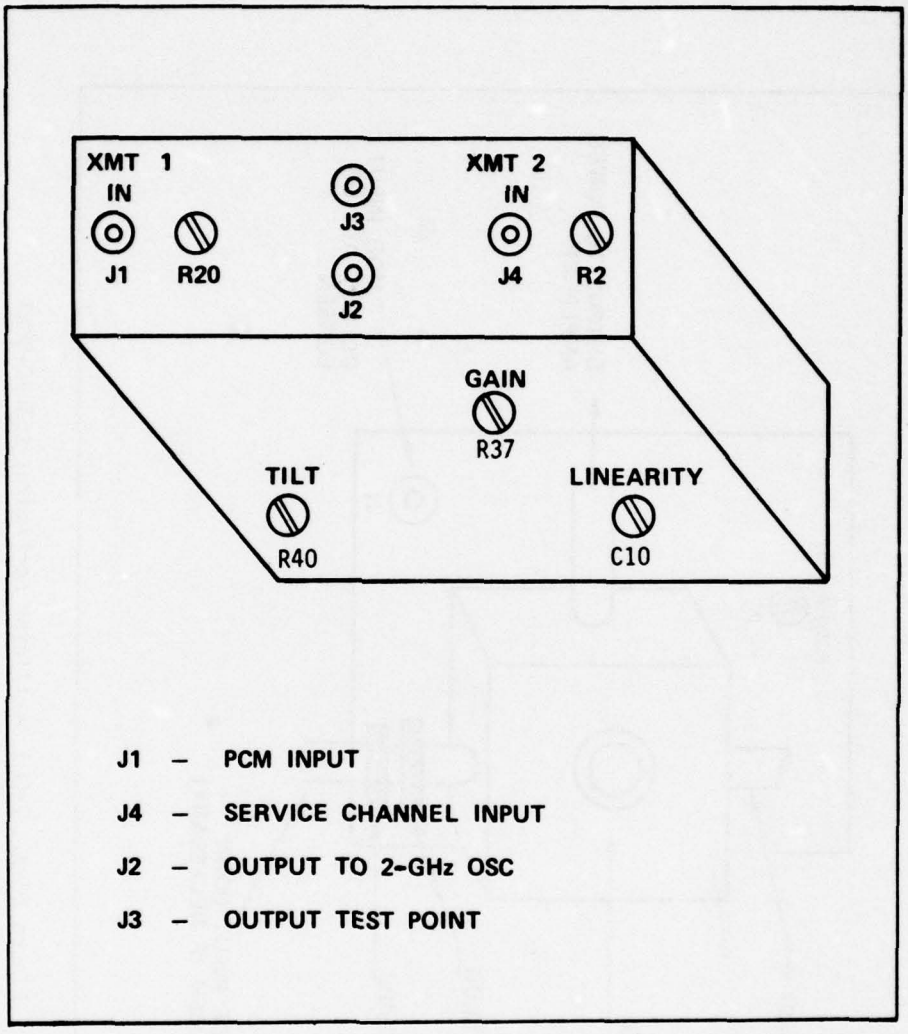


Figure 60-2. Modulator amplifier (27F2A-MW).

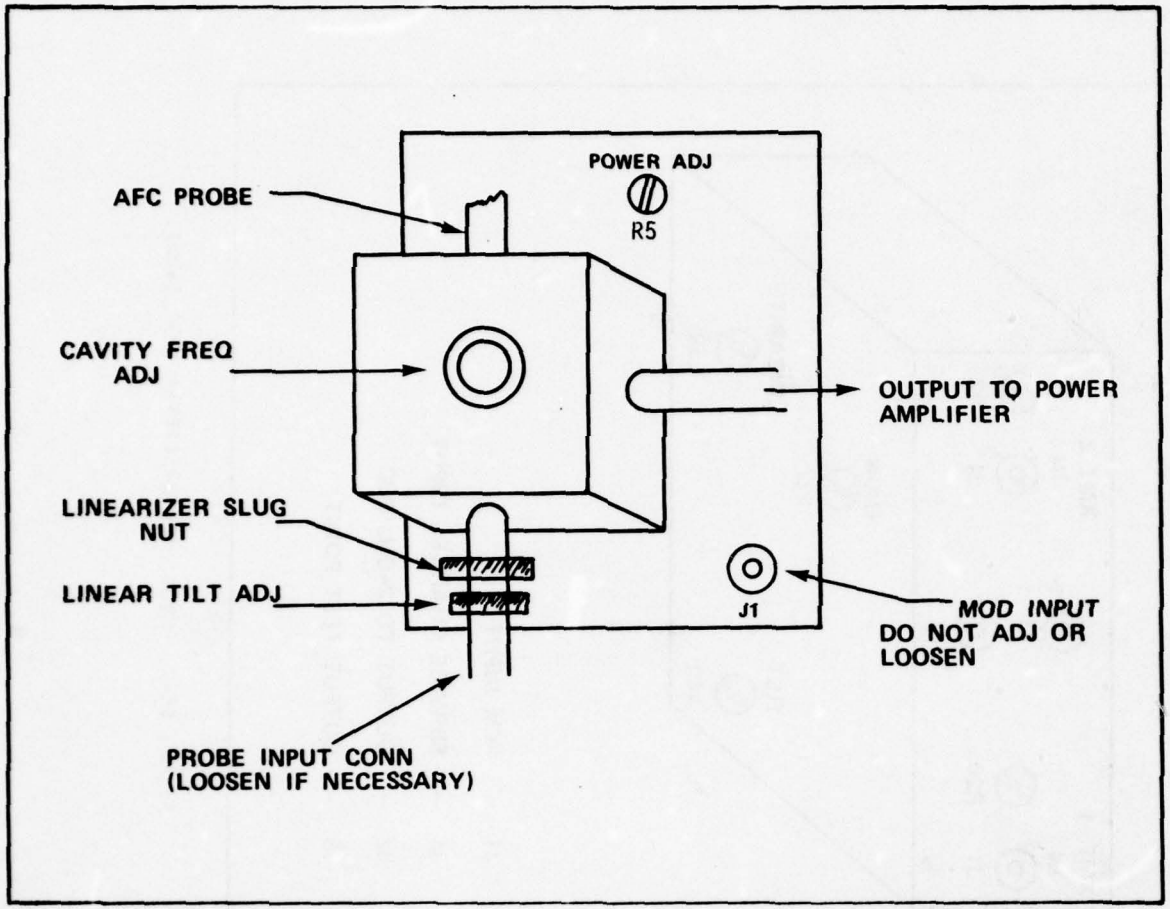


Figure 60-3. 2-GHz oscillator horizontal (62L2D-8MW).

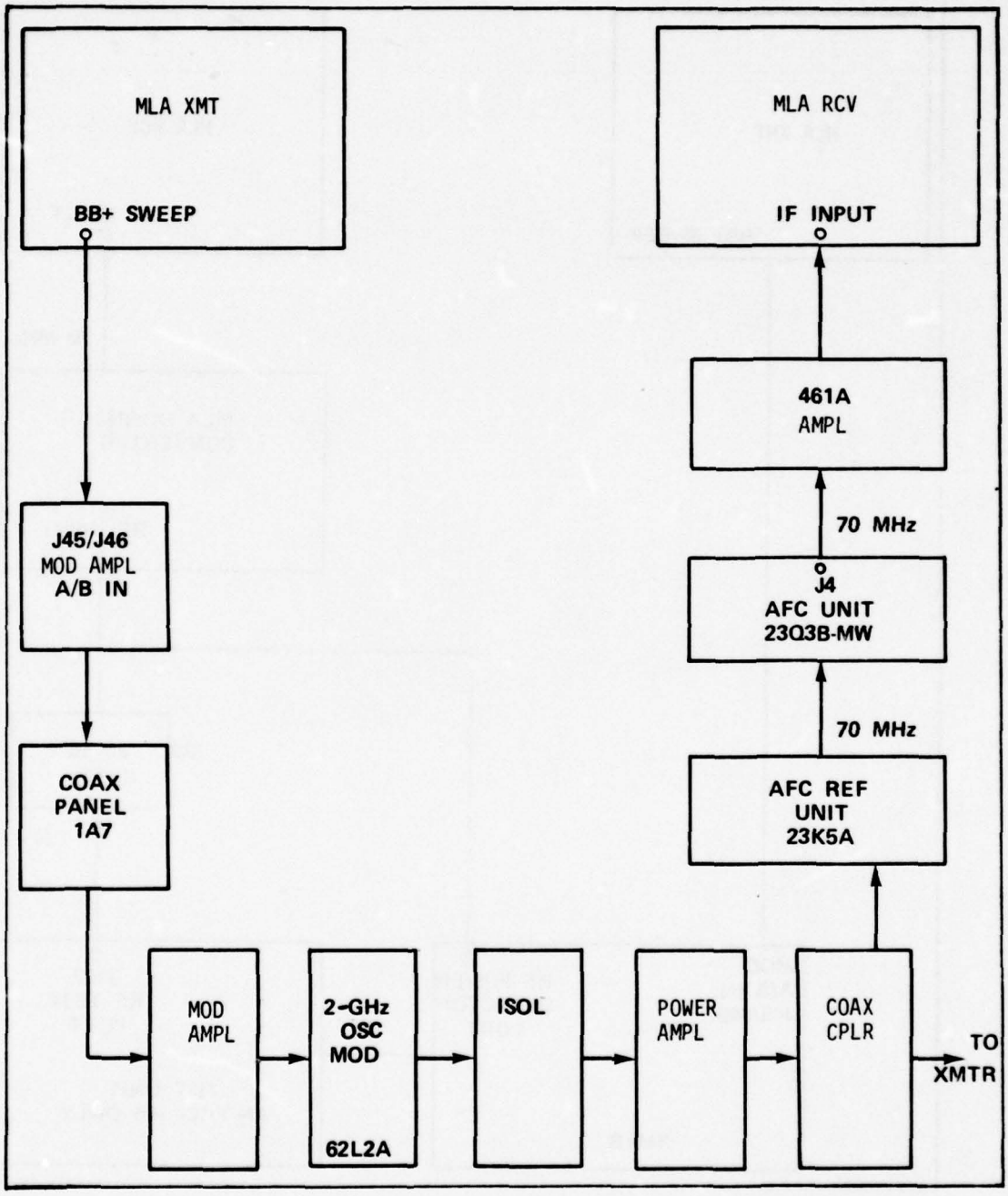


Figure 60-4. 2-GHz oscillator deviation and linearity test setup.

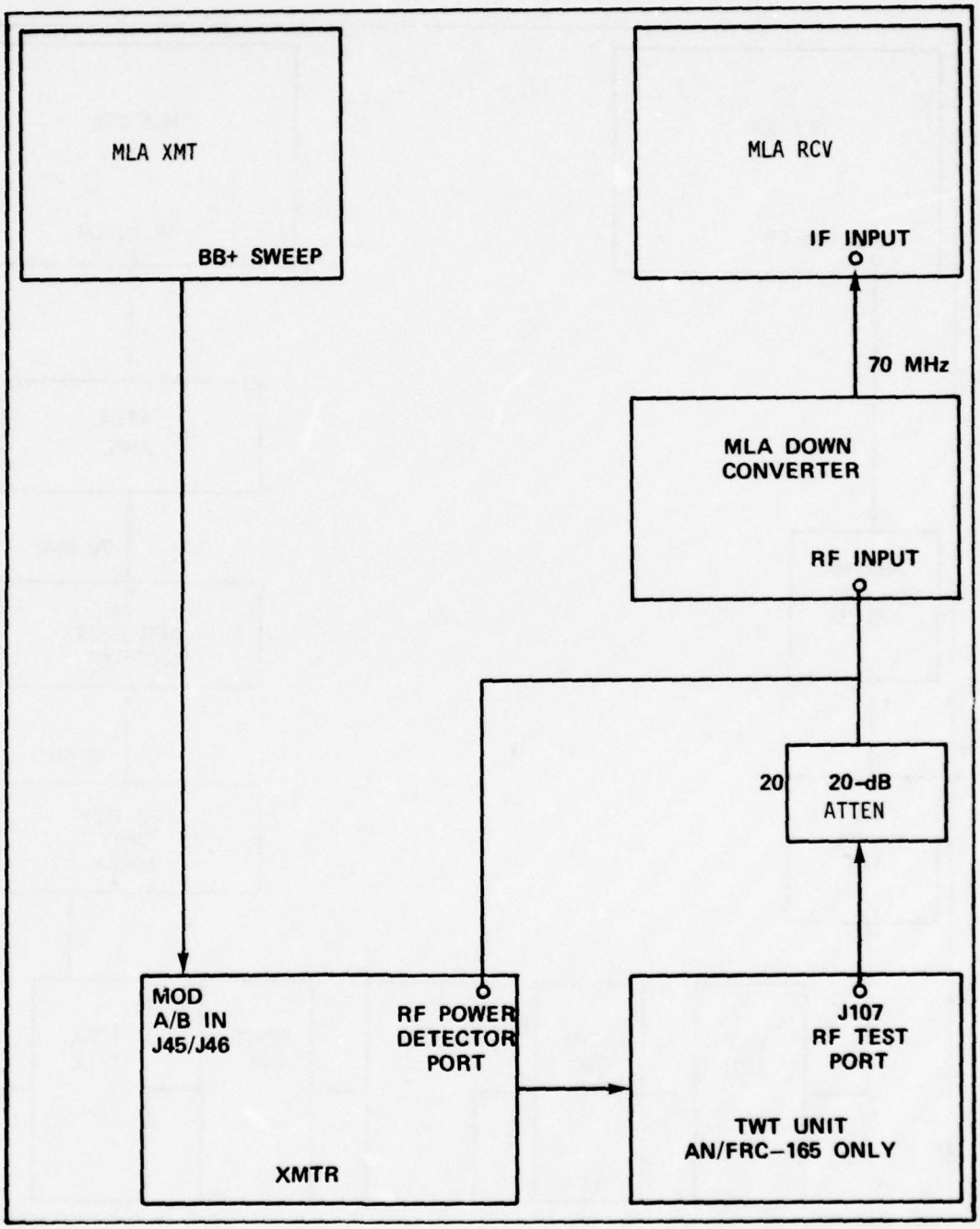


Figure 60-5. Baseband-to-RF linearity and delay test setup.

CHAPTER 61

RECEIVER RF INPUT VS AGC OR IF VOLTAGE (RECEIVER QUIETING) (DT-258)

61-1. GENERAL.

a. The purpose of this test is to:

(1) Calibrate the radio receiver in terms of the RF signal input power (or RSL) versus the AGC voltage (or the IF signal power (DC) voltage). Either the AGC voltage or the IF signal power (DC) voltage can then be used as a measure of the RSL.

(2) Measure the noise in selected slots of the baseband versus the RSL, that is, the noise quieting characteristics. As an option, instructions are included for making quieting test using the entire digital baseband. The digital baseband is normally much wider than the FDM baseband used in the majority of DCS installations. The quieting test results of the entire baseband can be compared to those of the slot frequencies.

b. The data from these measurements will be used to plot curves of: AGC voltage or IF power (DC) voltage and receiver noise quieting, each versus the radio receiver input power level (RSL). The AGC voltage or the IF power (DC) voltage curve provides a radio receiver calibration which can be used to measure the RSL. The quieting curves are used to determine the radio receiver 20-dB quieting point and to estimate the ratio FM threshold. The above measurements apply to single receivers.

c. Before performing these tests, the IF limiter and AGC performance should be checked in accordance with the applicable technical manuals or technical orders to ensure that it is operating properly.

d. The TLP at J5 or J6 of the AN/FRC-162 is nominally 13 dBm. In the past, when referring to FDM systems, the voice channel was equated to a 200-kHz deviation of the RF carrier. To maintain a semblence of this equivalency in a digital radio of the AN/FRC-162 type, the noise in the baseband is sampled with a frequency selective voltmeter occupying a slot approximately equal to the FDM voice channel. A correction should then be applied to the TLP to account for the difference of 200 kHz as compared to the normal deviation of 3.14 MHz produced by the partial response baseband. This is equivalent to $20 \log_{10} \frac{3.14 \text{ MHz}}{0.2 \text{ MHz}}$ or 24 dB. Thus a -11 dBm TLP is referenced instead of a 13-dBm TLP. It should be noted that the quieting curve can be constructed based on ordinate values of power in dBm without reference to a TLP. In the event the quieting test is made using the entire baseband, the curve should be plotted using values in -dBm.

e. This test is similar to DT-224. Either procedure will provide satisfactory results when properly performed.

61-2. SPECIFICATIONS. Refer to DT-224.

61-3. TEST EQUIPMENT REQUIRED.

a. Frequency selective voltmeter.

b. Spectrum display unit.

c. AC/DC voltmeter.

d. RF sweep generator (CW).

e. RF power meter.

f. Bolometer thermistor mount.

g. 70-MHz logarithmic amplifier/detector.

h. Variable attenuator.

i. 10-dB precision attenuator.

61-4. TEST PROCEDURES.

a. Establish the test setup shown in figure 61-1 and allow approximately 30 minutes for warmup and stabilization. if there is a question regarding the accuracy of the indicated power output of the generator, calibrate the generator power output by means of the bolometer thermistor and RF power meter. The calibration should be at the center frequency of the radio receiver.

NOTE: The 10-dB attenuator is inserted at the output of the generator to reduce impedance mismatch effects at this point.

b. On figure 27-1 (DD Form 2122) record the baseband slot width of the frequency selective voltmeter. Set the frequency selective voltmeter to terminate to match the baseband output impedance. Measure noise quieting in the following slot frequencies: 0.1, 1.1, 3.1, and 8.1 MHz. These frequencies will provide the best indicator of receiver quieting performance. The data sheet allows for taking the measurements at a number of different values of RSL. This will not be necessary when a preliminary or quick-look graph is needed, but all values should be considered when taking final test data.

c. Use either the AGC voltage or the IF signal power (DC) voltage (before the point in the receiver where AGC is applied) as a measure of the RSL. Methods employing out-of-band noise to measure the RSL are not acceptable. To find the RSL in terms of AGC (or IF signal power), refer to the test setup. Inject known values of RSL's into the receiver and enter these values on figure 27-1 (DD Form 2122). Construct a curve on figure 27-3 (USACC Form 596-R) using an appropriate scale for the ordinate value of AGC or IF power. This curve will be used in other tests to determine the RSL's of signals received over the operating link or in a back-to-back loop.

NOTE: Test point designations are based on the AN/FRC-162.

d. Insert the RF signal at the RF test input port (J4) of the 51G1B-MW mixer/pre-IF module. This is an easy access point and does not require removing waveguide sections. Since RSL is defined as the signal level at the input to the receivers (at top of waveguide stack), the losses between the stack input and the input to the 51G1B-MW module must be considered. Use the following formula to determine the power level at the input to the RF input test port (J4) of 51G1B-MW for a given RSL:

$$X = D + C - 1.7 \text{ (for receiver A)}$$

and

$$X = D + C - 1.9 \text{ (for receiver B)}$$

where X is the RF test port input level in dBm at the end of the cable

D is the desired value of RSL in dBm at stack input

C is the coupler loss value printed on the 51G1B-MW module.

For example, if the desired RSL for receiver A is -20 dBm and the coupler value is 21 dB

then $X = -20 + 21 - 1.7$

or $X = -0.7$ dBm.

e. Ensure that the FM1/FM2 switch inside the 86242A plug-in is in the FM1 position. Set the generator to CW mode and set the output frequency to the assigned receiver frequency. The generator ALC switch should be on internal.

f. Connect the 0- to 120-dB and 0- to 10-dB step attenuators to the RF output of the generator (figs. 61-1 and 61-2). Set the attenuators to zero attenuation and set the output power level at the end of the cable (value X in the above formula) to simulate a desired value of -20 dBm RSL. Ensure that the cable is fixed so that the movement of the cable does not change the power level.

g. Ensure that the receiver switch control (18R2A-MW) is switched (locked) to the receiver that is to remain in service. Close the waveguide shutter of the receiver under test.

h. Connect a jumper between squelch and ground on the 22E4C-MW module to ground out the squelch.

i. Connect the cable to the RF test port (J4) of the mixer/pre-IF module.

j. Connect the frequency selective voltmeter input to the J5 or J6 jack.

k. Alternately set up a 70-MHz logarithmic detector to J4 of the 22E4C unit.

l. Set the step attenuators to simulate an RSL of -100 dBm. Use the frequency selective voltmeter to measure the baseband noise in the four slots. Measure the AGC voltage at the AGC test point of the 22E4C module. Alternately measure the logarithmic detected voltage.

m. Repeat the above procedures for other RSL values. Enter the results on figure 27-1 (DD Form 2122) and plot the results on figure 27-3 (USACC Form 596-R).

61-5. DATA RECORDING AND ANALYSIS.

a. Determine the receiver 20-dB quieting points for the upper frequency slot measured from the curve by drawing a line at the point where the noise power is reduced 20 dB from its maximum value. Record the corresponding RSL on figure 27-1 (DD Form 2122). In a like manner, determine the 20-dB quieting points for the entire baseband curve.

b. Determine the FM threshold for the upper frequency slot measured by drawing a limiting curve adjacent to the measured curve and ascertaining the point or points at which a 1-dB separation occurs between the two curves (fig. 27-4). If the upper curve fails to produce a recognizable separation, draw the line on a lower frequency curve. Record the corresponding RSL's on figure 27-1 (DD Form 2122). Compare the measured values of FM threshold with the calculated value obtained from the following formula:

$$\text{FM threshold RSL (dBm)} = -164 \log B_{if} + NF$$

where: B_{if} = IF bandwidth in Hz

NF = receiver noise figure in dB

c. Compare the FM threshold using the curve of the entire baseband.

d. Review all test results for validity and summarize the test results on figure 3-7 (DD Form 2091).

e. Remove all test equipment and restore the system to its normal configuration.

f. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

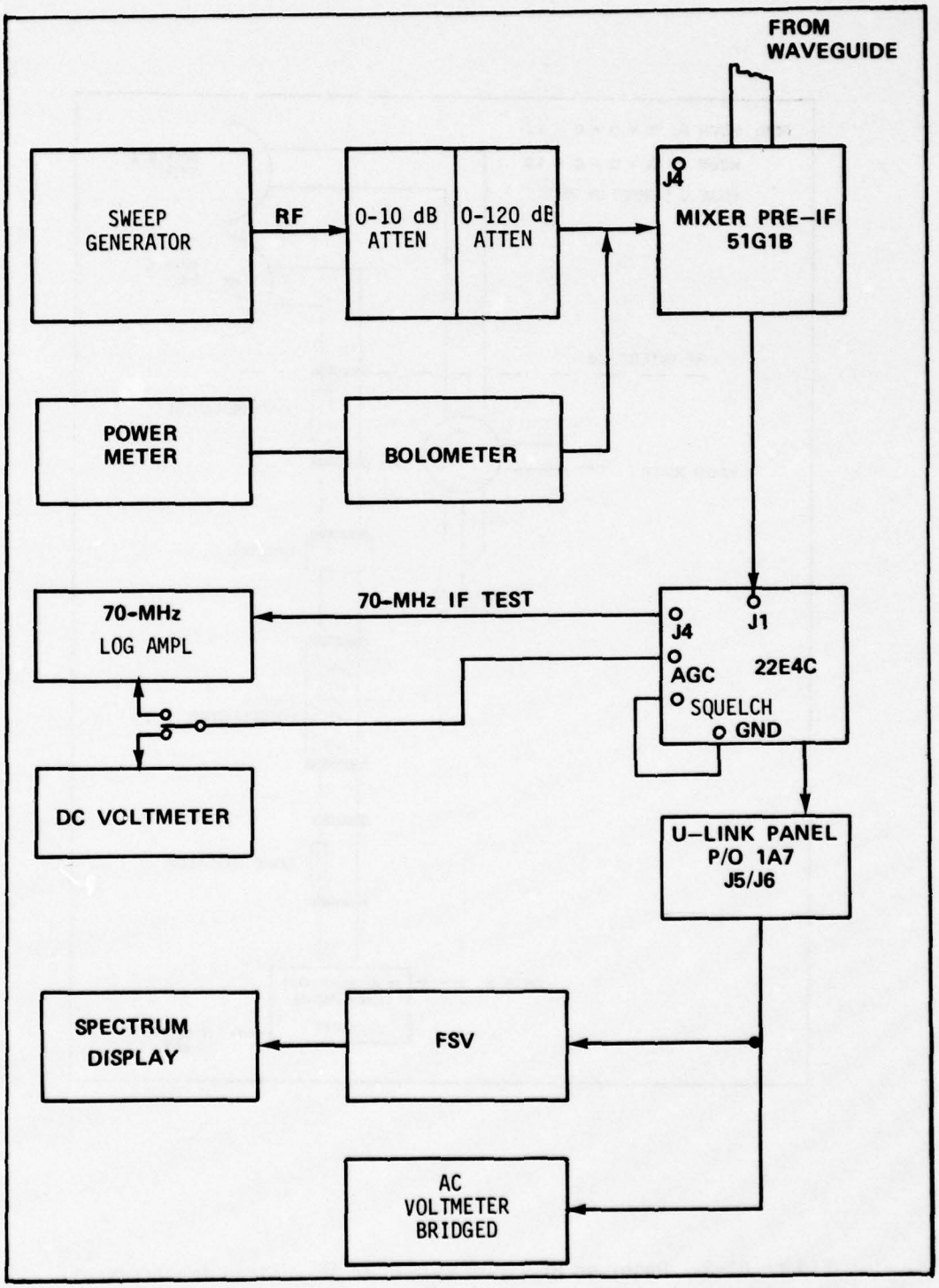


Figure 61-1. Receiver RF input vs AGC or IF voltage (calibration) test setup.

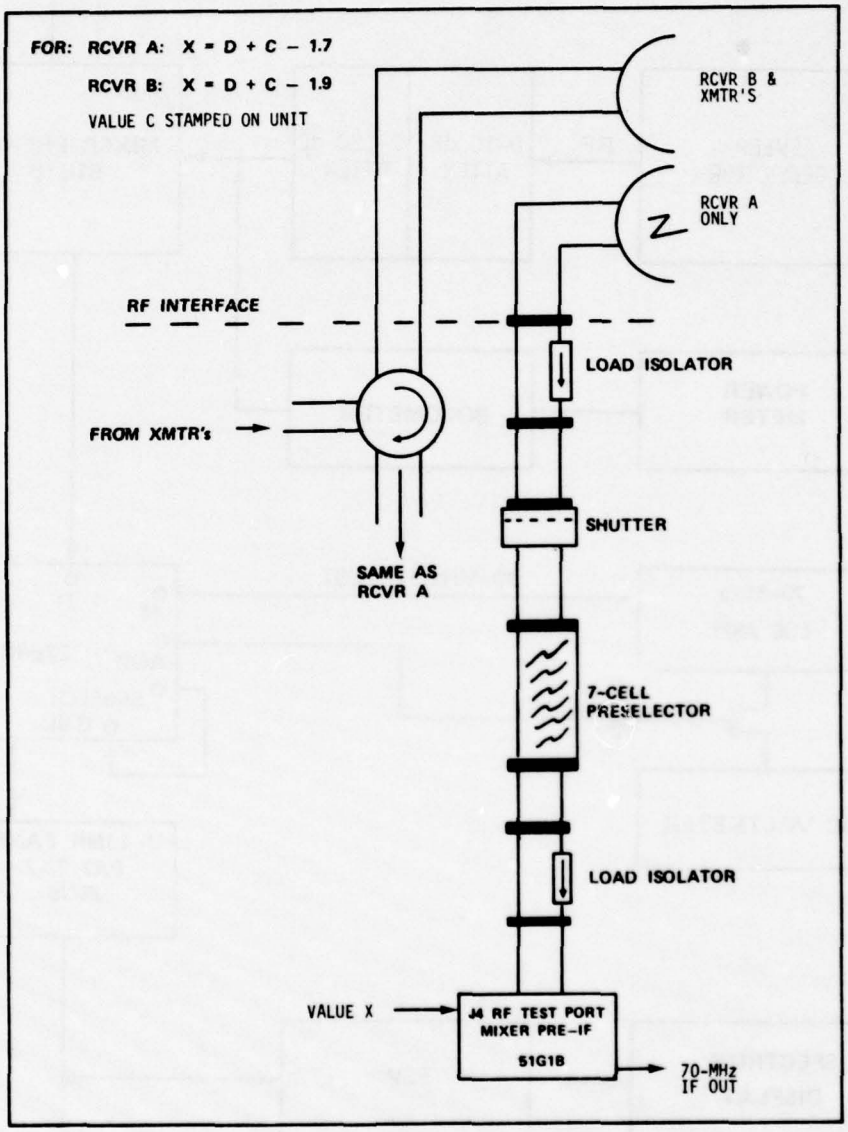


Figure 61-2. Receiver RF input vs AGC or IF voltage (measurement) test setup.

CHAPTER 62

RECEIVER BASEBAND LINEARITY AND GROUP DELAY (AN/FRC-162) (DT-259)

62-1. GENERAL.

a. The purpose of this test is to measure the linearity and delay of the receiver by using the microwave link analyzer system. The linearity and delay can be measured from RF to baseband and from IF to baseband. This test is also used to aline the receiver with the microwave link analyzer as a substitute for the Collins deviation calibrator. RF to baseband is usually performed as a preliminary check or a final verification of the total receiver performance. IF to baseband is performed as an alinement procedure in addition to preliminary and final testing.

b. This test is the same as DT-218 except that additional details are provided for the AN/FRC-162 test setup.

c. Either test may be used during onsite test activities.

62-2. SPECIFICATIONS. Refer to DT-218.

62-3. TEST EQUIPMENT REQUIRED.

a. Microwave Link Analyzer.

(1) HP 3710A IF/baseband transmitter.

(2) HP 3716 plug-in for HP 3710A.

(3) HP 3702B IF/baseband receiver.

(4) HP 3705A plug-in for HP 3702B.

(5) RF generator/sweeper/microwave link analyzer.

(6) Up converter RF plug-in for HP 8620 with microwave link analyzer option.

b. Power meter.

c. Frequency counter.

d. Wideband amplifier (if necessary).

62-4. TEST PROCEDURES.

a. IF-to-Baseband Linearity and Delay, and Baseband Level Adjustments.

(1) Perform the microwave link analyzer back-to-back checks in accordance with the operating instructions to verify proper performance (fig. 62-1).

(2) Set the microwave link analyzer controls as follows:

(a) Sweep to internal.

(b) Sweep width to 10 MHz.

(c) Deviation to 140 kHz.

(d) Baseband frequency to 555 kHz.

(e) IF to 70 MHz.

(f) Baseband input to external 75 ohms.

(g) Sweep source to external baseband.

(h) Blanking to on.

(i) Y1 display to IF.

(j) Y2 display to delay.

(k) Markers to ±5 MHz.

(3) Set the 70-MHz crystal/IF (uncalibrated) switch to the crystal position. Disconnect the cable at the output of the equalizer cam (40M5A-MW). Connect the 70-MHz crystal output to the cable through a 30-dB pad. This provides a -20 dBm signal to the IF input (J1 of 22E4C-MW) at exactly 70 MHz.

(4) At the subsystem control unit (18P2A-MW), set the meter selection switch to receive frequency. Adjust the IF amplifier discriminator zero control for a live-zero indication on the control unit meter.

(5) Remove the cable from the 70-MHz crystal output and remove the 30-dB pad. Set the 70-MHz crystal/IF (uncalibrated) switch to IF. Connect the transmitter IF auxiliary output to the receiver IF input. Adjust the IF attenuator for an on-scale reading on the IF/baseband level meter. Ensure that the AFC lock lamp is illuminated and the IF uncalibrated lamp is extinguished.

(6) Connect the IF output of the transmitter to the cable specified in subparagraph (5), above. Set the IF attenuator on the transmitter to provide a -20 dBm input to J1 of 22E4C-MW.

(7) Remove the termination from receive low level (J59) on the coaxial connector panel. Connect the receiver baseband input to J59. Set the Y1 display to baseband. Set the receiver baseband input attenuator for -33 dBm.

(8) Adjust the baseband gain adjust control (located on the outer end of 22E4C-MW) for a zero reading on the IF/baseband level meter. Remove the baseband input from J59 (reconnect the termination to J59).

(9) Connect the baseband input to J5 (receiver A) or J6 (receiver B). Set the receiver baseband input attenuator for -11 dBm. Adjust the high level baseband adjust control of the 22E4C-MW for a zero reading on the IF/baseband level meter. Do not use a bridging U-link. Remove the U-link provided and connect the microwave link analyzer directly to J5/J6. Leaving a connection to the receive switch jacks will distort the linearity measurement.

(10) Turn the blanking off and adjust the X-phase-shift control to superimpose the forward and return traces. Turn the blanking on.

(11) Calibrate the Y1 trace for 1 percent per division. Calibrate the Y2 trace for 1 nsec per division. The microwave link analyzer should now display linearity and delay over 10 MHz. Adjust the IF amplifier (22E4C-MW) linearity tilt (C22) and linearity bow (R27) for optimum performance. Linearity should be within 1 percent, delay slope within 1 nsec, and delay parabolic within 6 nsec.

(12) Photograph the traces and mount the photographs on figure 5-2 (DD Form 2093). Enter the linearity delay slope and delay parabolic readings on the data sheet. An example of a delay and linearity trace is shown in figure 21-2.

b. RF-to-Baseband Linearity and Delay.

(1) Perform a microwave link analyzer back-to-back test in accordance with the equipment manual to verify proper operation (fig. 62-2).

(2) Turn the generator to the CW mode and connect a frequency counter to the generator output. Set the generator to the center frequency of the receiver under test.

(3) Set the generator RF output power to the desired level (the RF test port of unit 51G1B-MW or the waveguide input to the receiver) to simulate the median RSL. Connect the generator output to the receiver RF input.

(4) Connect the microwave link analyzer transmitter sweep out to the up converter sweep in. Connect the transmitter baseband plus sweep to the up converter baseband in.

(5) Turn the FM1/FM2 switch inside the HP 86242A plug-in to FM2.

(6) Set the microwave link analyzer controls as follows:

(a) Transmit baseband power to -28 dBm.

(b) Sweep calibration to fully counterclockwise.

(c) Sweep vernier to fully clockwise.

(d) Sweep source to external baseband.

(e) Sweep width to 10 MHz.

(f) Baseband input to external 75 ohms.

(g) Baseband frequency to 555 kHz (both units).

(h) Y1 display to IF.

(i) Y2 display to delay.

(j) Markers to ±5 MHz.

(k) Blanking to on.

(7) Connect the receiver 70-MHz test jack (J4) of unit 22E4C-MW to the IF input of the microwave link analyzer receiver. Adjust the IF attenuator for an on-scale reading of the IF/baseband level meter. If there is insufficient gain to drive the microwave link analyzer input, use a wideband amplifier as shown in figure 62-2. Verify that the AFC lock lamp is illuminated and the IF in calibration lamp is extinguished.

(8) Connect the baseband input to the J5/J6 receiver output test point and turn the sweep level control slowly clockwise until the markers reach the edge of the trace.

(9) Turn the blanking off and adjust the X-phase-shift control until the forward and return traces are superimposed. Turn the blanking on.

(10) Set the Y1 display to baseband and adjust the baseband input attenuator to give an on-scale reading on the IF/baseband level meter.

(11) Calibrate the Y1 trace for 1 percent per division and the Y2 trace for 1 nsec per division of delay. The microwave link analyzer should now display linearity and delay over 10 MHz.

(12) Photograph the traces and mount the photographs on figure 5-2 (DD Form 2093). Enter the linearity, delay slope, delay parabolic, and other pertinent information on the data sheet. An example of a delay and linearity trace is shown in figure 21-2.

62-5. DATA RECORDING AND ANALYSIS.

a. Ensure that all pertinent information is entered on the data sheet. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

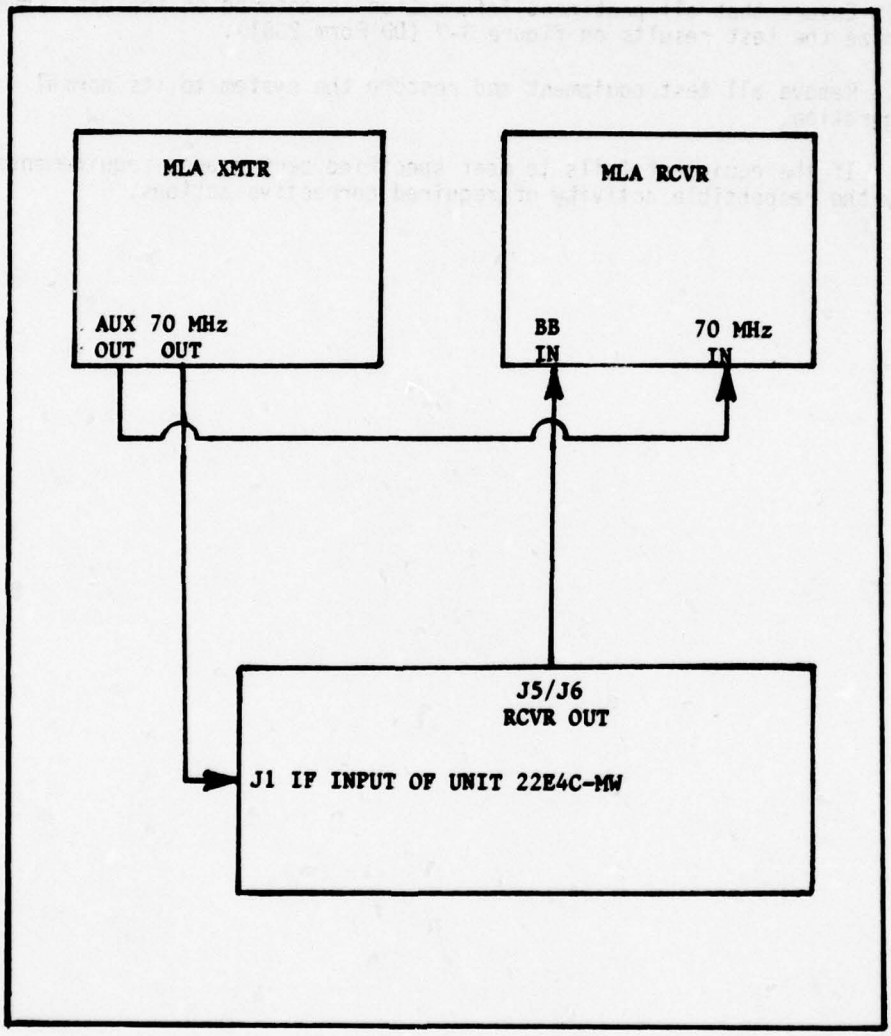


Figure 62-1. Receiver baseband linearity and group delay (IF to baseband) (AN/FRC-162) test setup.

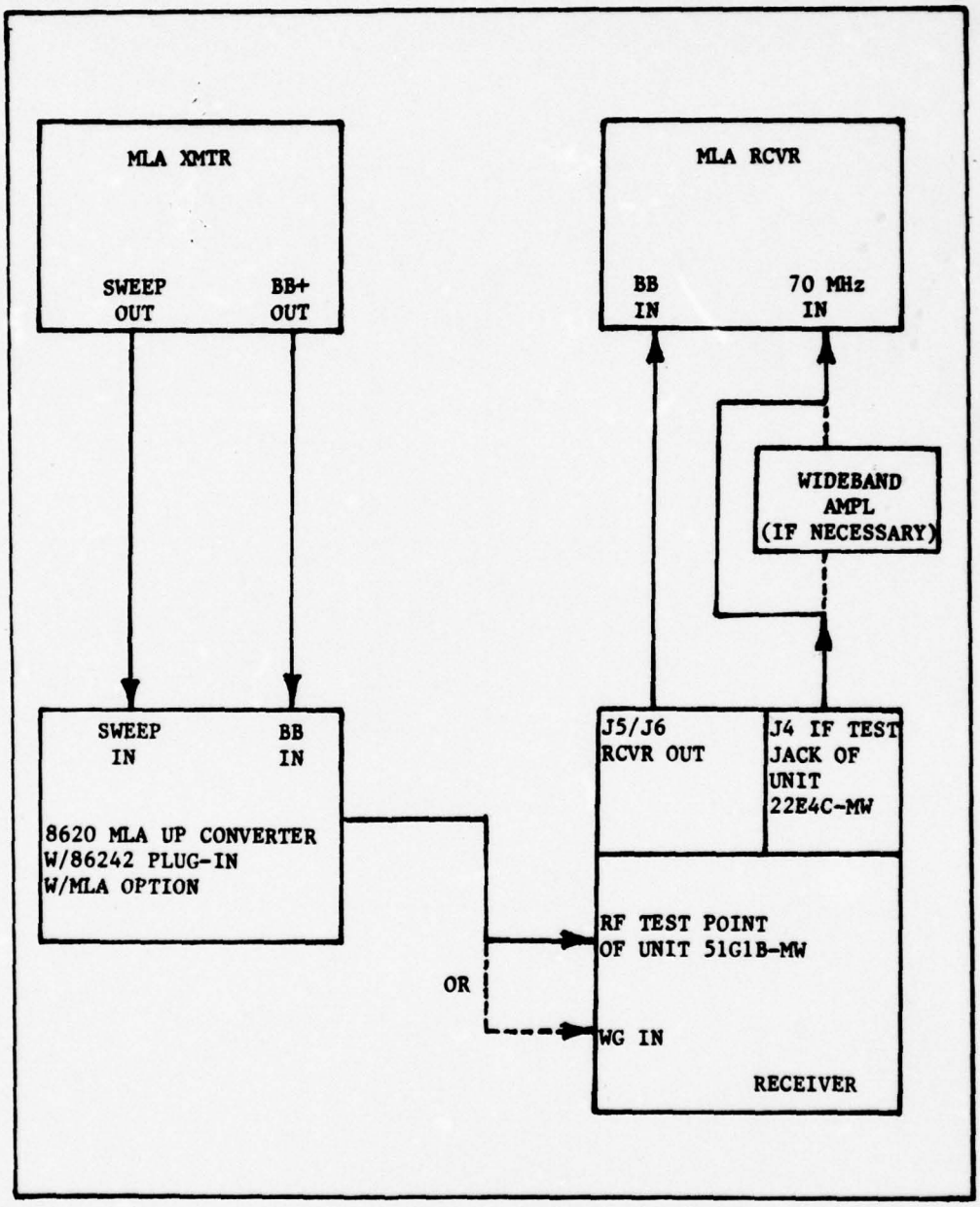


Figure 62-2. Receiver baseband linearity and group delay (RF to baseband) (AN/FRC-162) test setup.

CHAPTER 63

FAULT ALARM STATUS REPORTING (FASR) EQUIPMENT (DT-260)

63-1. GENERAL.

a. The purpose of this test is to verify the performance of the FASR equipment.

b. The FASR as used in the AN/FRC-162 and VICOM 4000-2 system will display and sequentially encode a maximum of 26 faults. The occurence of a fault will activate a buzzer, and the appropriate red alarm status light will illuminate. The status alarm light will remain lighted until the fault is cleared; however; the audible alarm may be manually inhibited. Frequency shift keying (FSK) tone transmitters are included for those stations requiring remote monitoring. The receiving terminal will receive and decode the remote fault status as communicated by the fault transmitter. The fault information is connected to isolated dry contact closures for remoting to a TCF.

c. The local relay/display terminal interconnects with the station fault sensors and provides a local display at the FASR equipment and dry relay contacts for remoting the alarm to the TCF.

d. Table 63-1 contains some of the more salient characteristics of the FASR equipment. A typical block diagram of the FASR equipment is shown in figure 63-1.

e. This test may be performed on contractor EF&I systems to ensure that they meet specified performance levels. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

63-2. SPECIFICATIONS.

a. For the AN/FRC-162 and the VICOM 4000-2, refer to table 63-1.

b. The radio shall operate as specified in the standard engineering plan or contract specifications.

63-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. Voltmeter.

c. Ohmmeter.

d. Audio sweep generator.

e. Audio analyzer.

f. X-Y recorder.

g. Frequency selective voltmeter.

h. Cables, connectors, and adapters, as required.

63-4. TEST PROCEDURES.

a. Tone Transmitter and Receiver Back-to-Back Check.

(1) *Transmitter.*

(a) Connect the tone transmitter output to the level meter as shown in figure 63-2a.

(b) Terminate the transmit test tone into 75 ohms and allow approximately 30 minutes for warmup and stabilization. Measure the output level with the level meter. The level should be -15 dBm ±2 dB. Record the level on figure 63-3 (USACC Form 656-R).

(c) Using the frequency counter or frequency selective voltmeter, measure and record the tone transmitter output frequency.

(d) Connect the tone output to the receiver input as shown in figure 63-2a, and in turn, place a short across the pins shown in table 63-2. Observe that the appropriate lamp on the display illuminates. Record compliance or noncompliance on the data sheet.

(e) Connect the tone transmitter output to the 75-ohm terminated level meter. Using the tone level adjust control, verify that the output can be varied from +2 to -30 dBm.

(f) As directed, verify the output impedance of the transmitter by performing DT-280.

(g) As directed, verify the transmit tone output level stability by recording the tone for 30 days as described in DT-311.

(2) *Tone receiver/display.*

(a) Connect the tone transmitter output to the receiver input and adjust the transmit tone for -15 dBm.

(b) In turn, short the pins shown in table 63-2. Observe that the appropriate alarm indicator illuminates and that the external relay contacts change state. Record compliance or noncompliance on the data sheet.

(c) As directed, determine the bandwidth by connecting an audio sweep generator to the tone receiver input. The generator output level should be set

for -15 dBm and the sweep range for 200 Hz each side of the center frequency. Record compliance or noncompliance on the data sheet. If required, plot the response on figure 3-4 (DD Form 2094).

(d) As directed, perform the input impedance test as described in DT-280. Record the results on the data sheet.

b. System Testing.

(1) Connect the test equipment as shown in figure 63-2b.

(2) Adjust the tone transmitter output for -15 dBm. Measure and record the level and frequency on the data sheet. Connect the tone transmitter output to the supervisory baseband input of the radio transmitter.

(3) At the distant terminal, measure the received tone level and frequency and record the readings on the data sheet. If intermediate remote terminals are involved, each terminal should measure the tone level.

(4) Connect an RMS voltmeter terminated in 75 ohms to the radio receiver supervisory channel out and, if necessary, adjust the radio service channel (R36) for a level of -15 dBm ±0.5 dB as read on the RMS voltmeter.

NOTE: This measurement should be performed with only one station transmitting at a time. It may be necessary to remove the tone transmitter at the other stations when performing the measurement.

(5) Simulate the failures as shown in table 63-3. Observe that the applicable alarm indicator illuminates, the audible alarm buzzer sounds, and the remote alarm indicator contacts change state. Record the results on the data sheet.

NOTE: Table 63-3 reflects a typical arrangement of alarm functions. These may change based on station requirements; therefore, verify the data from the onsite plant-in-place records.

63-5. DATA RECORDING AND ANALYSIS.

a. Ensure that all data is accurate and complete. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

Table 63-1. FASR Characteristics

TRANSMITTING DISPLAY/ TERMINAL	PERFORMANCE CHARACTERISTIC
Inputs	36 minimum with at least one common return for every eight inputs
Input source	Dry contact closure: 50,000 ohms minimum (open) 1,000 ohms maximum (closed)
Input mode	Close for alarm
Coding format	NZR with parity check of: 1 bit per point 6 bits per point 14 bits frame synchronization
Scan time	3 seconds or less
Frequency	4.4 to 7.6 kHz, depending on installation
Keying speed	±60 b/s
Frequency shift	±60 Hz
Channel spacing	350 Hz
Output	Single
Level output	Adjustable for a -30 to +2 dBm
Impedance	75 ohms
Level stability	±1 dB over a 30-day period
Audible alarm	-48 VDC ±10%, resettable
Input impedance	75 ohms
Input level	-15 dBm nominal; -45 to +10 dBm, adjustable

Table 63-1. FASR Characteristics (continued)

TRANSMITTING DISPLAY/ TERMINAL	PERFORMANCE CHARACTERISTIC
Bandwidth	120 Hz
Bit error rate	$1x10^{-6}$ for SNR of 10 dB
Number of indicators	
Local	36 minimum
Remote	108 minimum
Number of tone receivers	3, depending on requirements
Outputs	36 for each receiver
Power input	-48 VDC
MTBF	5,000 hours, 90% confidence level
MTTR	30 minutes, maximum time to repair; 60 minutes 90% of the time

Table 63-2. Fault Alarm Simulation (Back-to-Back)

LAMP	SHORT PINS OF WIRE BLOCK	LAMP	SHORT PINS OF WIRE BLOCK
1	1&2	19	37&38
2	3&4	20	39&40
3	5&6	21	41&42
4	7&8	22	43&44
5	9&10	23	45&46
6	11&12	24	47&48
7	13&14	25	49&50
8	15&16	26	51&52
9	17&18	27	53&54
10	19&20	28	55&56
11	21&22	29	57&58
12	23&24	30	59&60
13	25&26	31	61&62
14	27&28	32	63&64
15	29&30	33	65&66
16	31&32	34	67&68
17	33&34	35	69&70
18	35&36	36	71&72

Table 63-3. Typical FASR Monitor Functions and Simulated Faults

ITEM	MONITOR FUNCTION	SIMULATED FAULT
1	XMT power out, radio A	Remove power monitor cable
2	XMT AFC, radio A	Turn AFC off
3	XMT pilot, radio A	Press osc pilot alarm test
4	Receiver squelch, radio A	Remove preamplifier cable
5	Receiver switch, A to B	Remove preamplifier cable
6	XMT power out, radio B	Remove power monitor cable
7	XMT AFC, radio B	Turn AFC off
8	XMT pilot, radio B	Press osc pilot alarm test
9	Receiver squelch, radio B	Remove preamplifier cable
10	Receiver switch, B to A	Remove preamplifier cable
11	Major multiplex alarm	Remove multiplex group card
12	Minor multiplex alarm	Go to standby unit
13	Office alarm	Busy out channels
14	Battery charger	Turn off or reduce charge rate to zero
15	Illegal entry	Open door
16	Fire, general	
17	Fire, building	
18	Flooding, building	
19	Low fuel alarm	
20	DC/AC Inverter	
21	Waveguide pressure system	
22	Tower lights	
23	Through XX as required	

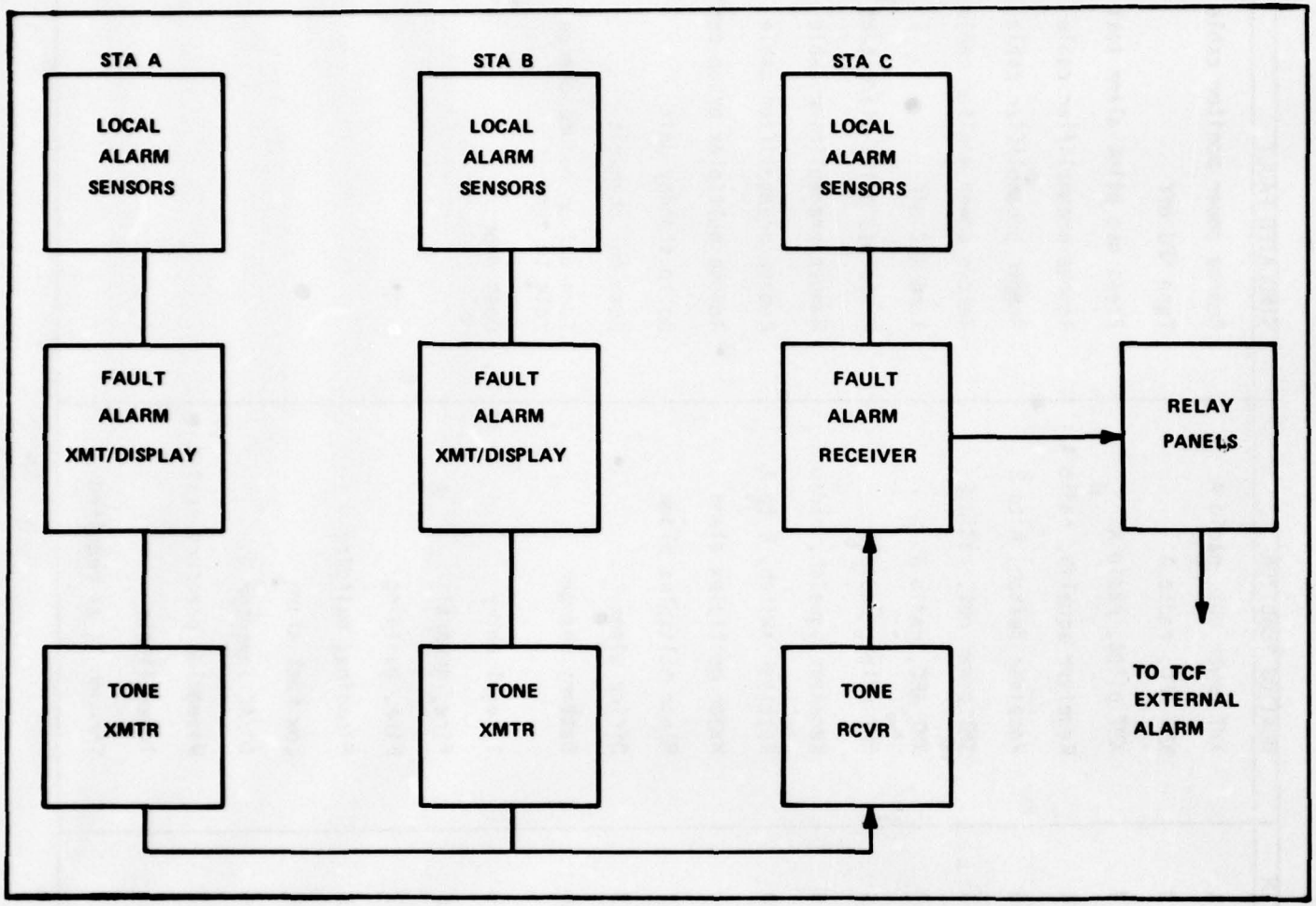


Figure 63-1. Typical block diagram of FASR equipment.

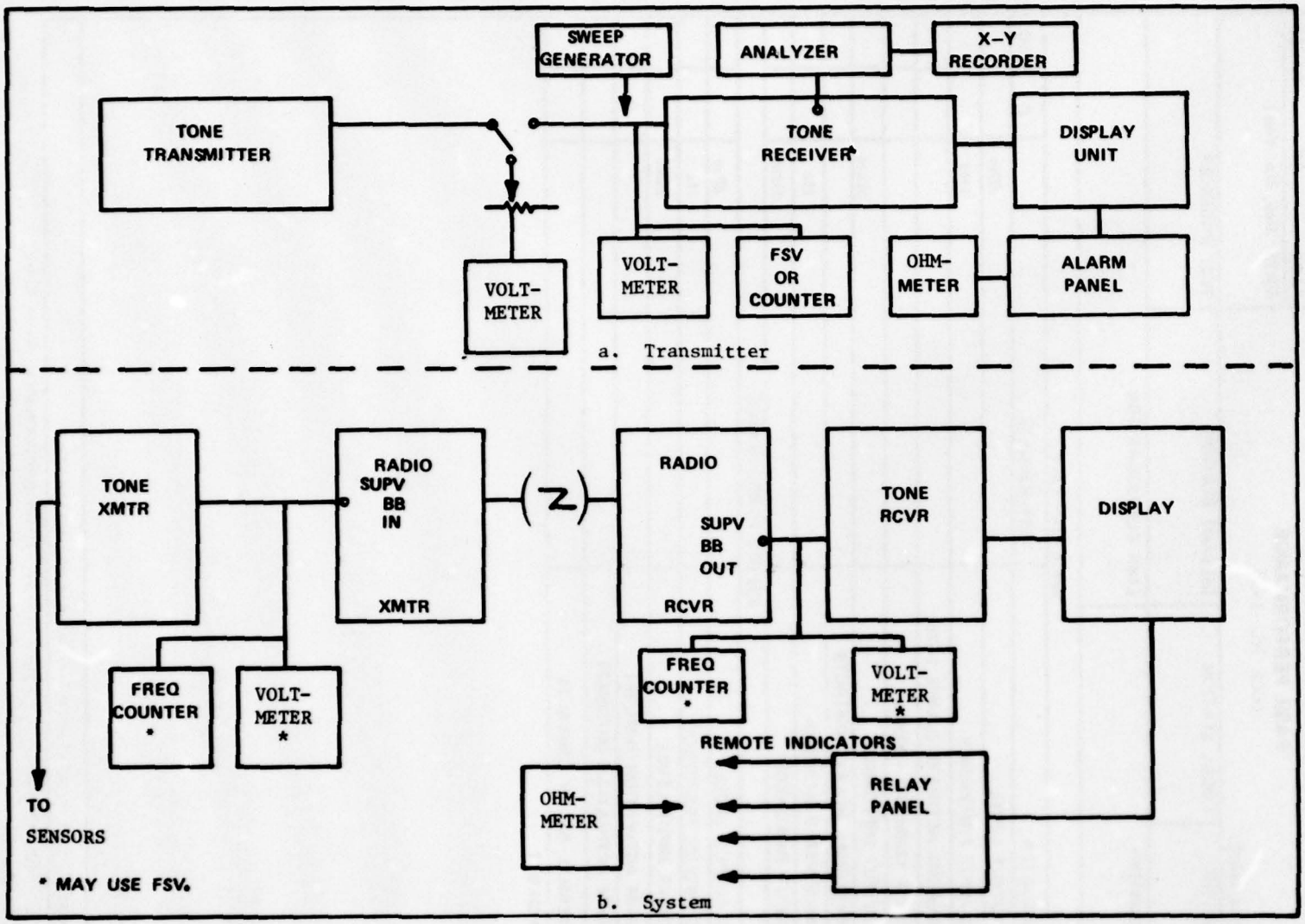


Figure 63-2. FASR equipment test setup.

CCP 702-11

FASR PERFORMANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		LINK CONFIGURATION	

BACK-TO-BACK			
PARAMETER	TEST RESULTS	C	NC
OUTPUT LEVEL	dBm		
OUTPUT FREQUENCY	kHz		
ALARMS ACTIVATE (LAMPS 1-38)			
OUTPUT +2dBm TO -30dBm			
OUTPUT IMPEDANCE	ohms		
EXTERNAL RELAY CONTACTS			
RECEIVER BANDWIDTH	Hz		
INPUT IMPEDANCE	ohms		
SYSTEM PERFORMANCE			
XMT OUTPUT LEVEL	dBm		
XMT OUTPUT FREQUENCY	Hz		
RECEIVE INPUT LEVEL	dBm		
ALARM ACTIVATION (VISUAL)			
ALARM ACTIVATION (AUDIBLE)			
EXTERNAL RELAY CONTACTS			

COMMENTS

NOTE: C = compliance NC = noncompliance

USACC FORM 656-R
1 MAY 79

Figure 63-3. FASR performance data sheet.

CHAPTER 64

DATA CHANNEL AND MULTIPLEX INPUT/OUTPUT INTERFACE PERFORMANCE (DT-261)

64-1. GENERAL.

a. The purpose of this test is to verify the performance level of the TD-1192 (AN/FCC-98) multiplexer/demultiplexer when interfaced with other digital equipment. This test will determine whether or not the BER of the digital interface equipment is degraded when connected to the TD-1192 (AN/FCC-98) multiplexer/demultiplexer. Typical equipment that the multiplexer interfaces with are:

(1) Digital-to-analog converter CV-3034.

(2) Multiplexer set AN/GSC-24.

(3) TSEC/KG-81.

(4) Multiplexer, VICOM 4000-2.

b. Interface parameters for the above equipment are contained in tables 64-1 and 64-2.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. Normally, however, it would only be performed during initial equipment acquisition.

64-2. SPECIFICATIONS.

a. The following criteria applies to the multiplex equipment (CCC-74047).

(1) The multiplex terminal shall interface with the AN/GSC-24(V) and CV-3034 at the data rate of the 50-kb/s data channel.

(2) The interface between the multiplex terminal and the digital equipment (AN/GSC-24 and CV-3034) shall not increase the BER performance of the digital equipment when data is provided by the digital equipment looped through the multiplex terminal.

(3) The multiplex terminal shall interface with the equipment listed in paragraph 64-1a, above, at the stated multiplex output/demultiplex input nominal data rates of the multiplex terminal.

(4) The interface between the multiplex terminal and the digital equipment shall not increase the BER performance of any data channel of the multiplex terminal when the output is looped through the digital equipment.

b. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

64-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Oscilloscope.

c. RMS voltmeter.

d. Noise test set.

e. Oscillator.

f. Frequency counter.

64-4. TEST PROCEDURES.

a. General.

(1) Connect the test equipment as shown in figure 64-1 and allow approximately 30 minutes for warmup and stabilization.

(2) If using the CV-3034 converter, connect it for input/output hybrid operation and set the BER test set for 135 ohms impedance. If the BER test set does not have a 135-ohm input/output impedance, use an impedance matching network. If using the AN/GSC-24, ensure that the unit is configured to transmit and receive 50 kb/s of data on at least one channel. All other channels can be terminated or configured for data or voice as required.

b. CV-3034 Interface.

(1) On the CV-3034, connect the BER test set output to J3 and set the level to -10 dBm as read on the RMS voltmeter. If the BER test set is to provide timing, remove any strap between terminals 1 and 2 of J10. If timing is to be derived from the CV-3034 rather than the BER test set, place a strap between terminals 1 and 2 of J10.

(2) Patch the transmitter output (J4 clock, J5 data) to the receive input (J7 clock, J8 data).

(3) With the CV-3034 in a loop configuration, measure and record the following levels on figure 64-2 (USACC Form 657-R).

(a) Adjust the transmit input hybrid level data signal to -10 dBm.

(b) Adjust the transmitter output signal level for ±3 volts bipolar.

(c) Adjust the receiver output for 0 dBm.

(4) Transmit a 50-kb/s bipolar data signal for approximately 15 minutes and record the number and the percentage of errors on the data sheet.

(5) Once the CV-3034 operation has been verified, connect the CV-3034 to the TD-1192 as shown in figure 64-1.

c. TD-1192 Interface.

(1) Configure one voice channel for 50-kb/s data operation by replacing the voice frequency channel card with the appropriate data card.

NOTE: The TD-1192 has 3-, 6-, 12-, or 24-channel operation. Table 64-3 shows a typical interleaving of data channels that the TD-1192 can accommodate.

Table 64-3. Data Channel Interleaving Capability

DATA INTERLEAVING CHANNELS	3/6/12/24-CHANNEL VERSION CHANNEL MODE				24-CHANNEL VERSION DATA FORMAT	
	3	6	12	24	BIPOLAR	NRZ
0-20 kb/s asynchronous	3	6	12	12	12	12
50 kb/s asynchronous	3	6	12	12	12	12
56 kb/s synchronous	3	6	12	12	12	12
64 kb/s synchronous	--	3	9	12	12	12
128 kb/s synchronous	--	1	4	12	6	12
256 kb/s synchronous	--	--	2	6	3	6
512 kb/s synchronous	--	--	--	1	1	1

(2) Initially, place the TD-1192 in a self-test loop and with the built-in test pattern generator adjusted for 50 kb/s, transmit data. Observe the number of errors on the error detector or frequency counter. Record the number of errors on the data sheet.

(3) Remove the self-test loop and connect the CV-3034 output to the transmit channel that was configured for 50-kb/s operation in subparagraph (1), above.

(4) Adjust the TD-1192 channel input for ±3 volts and record this value on the data sheet.

(5) Connect the TD-1192 1.544 mb/s data output to the receive data input. This may be accomplished from a separate patch panel or at the built-in panel.

(6) As directed, insert a 1020-Hz test tone at -10 dBm or Gaussian noise into the remaining voice frequency channels of the TD-1192.

NOTE: Observe the proper impedances and the balanced and unbalanced options provided with the equipment.

(7) Transmit data from the BER test set. Observe and record the number and percentage of errors on the data sheet. The error rate should not exceed that obtained in paragraph 64-4b(4), above.

d. AN/GSC-24 Interface.

(1) Connect one channel of the TD-1192 for 50-kb/s operation by inserting a voice frequency channel card.

(2) Connect the equipment as shown in figure 64-3 and perform a self-check test on the AN/GSC-24 as outlined in TM 11-5805-688-14-1.

(3) As directed, load the remaining channels of the TD-1192 with Gaussian noise or an oscillator set for 1020 Hz at a composite level not to exceed 0 dBm. On the receive TD-1192, terminate all channels into 78 ohms except those used for the 50 kb/s of data. As directed, insert the noise test set into unused channels of the AN/GSC-24. The level of the individual channels should not exceed -16 dBm.

(4) Refer to chapter 3 of TM 11-5805-688-14-1 to determine the number of ports required, the quantity of fill bits, and the procedures for setting the individual cards of the AN/GSC-24.

(5) Connect the multiplex output to the demultiplex input and transmit data for approximately 15 minutes. Record the number of errors.

(6) Remove the loopback and connect the AN/GSC-24 to the TD-1192 multiplex input/output. Transmit data for approximately 15 minutes. Record the number of errors. The number of errors received should not exceed those noted in subparagraph (5), above.

e. Input/Output Interface.

(1) Connect the test equipment as shown in figure 64-3, and set the multiplexer/demultiplexer (TD-1192) for 3-channel operation. Ensure that the equipment is alined in accordance with TM 11-5805-711-12.

(2) Before connecting the TD-1192 to the AN/GSC-24, VICOM 4000-2 or TSEC/KG-81, perform a back-to-back BER test on these equipments at a 50-kb/s rate in order to establish a baseline when the TD-1192 is interfaced with the equipment.

(3) On the TD-1192, replace one voice frequency channel card with a 50-kb/s data module and set the BER test set for 50-kb/s operation. Adjust the BER test set transmit level for -16 dBm, 78-ohm balanced. Refer to the technical manual for appropriate strapping of the TD-1192. The TD-1192 voice frequency channel output should be strapped for +7 dBm. Measure and record the levels at points (A) through (F) as shown in figure 64-3.

(4) Once the TD-1192 BER performance baseline has been established in accordance with subparagraph (2), above, connect the AN/GSC-24 or VICOM 4000-2 as shown in figure 64-4. Transmit 50 kb/s data and note any errors that occur on the receive BER test set.

NOTE: Ensure that these equipment input/output data rates, levels, and impedances are compatible with the TD-1192.

(5) Repeat the above with the TD-1192 and interface equipment configured for 6-channel (384 kb/s), 12-channel (768 kb/s), and 24-channel (1.544 mb/s) operations. Record the results on the data sheet.

(6) Connect the TD-1192 multiplex/demultiplex to the TSEC/KG-81 as shown in figure 64-4 and repeat the BER test at the rates shown in subparagraph (5), above. Record the results on the data sheet.

64-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the recorded data for compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the TD-1192 fails to interface properly or test results indicate an increase in BER over the established threshold, notify the responsible activity of required corrective actions.

Table 64-1. Input/ Output Characteristics of Converter CV-3034

TRANSMITTER	
Input voice mode	Nominal 3-kHz voice band signal
Signal level	-46 to -16 dBm (low level) or -30 to 0 dBm (high level)
Input impedance	600 ohms, balanced
Input hybrid mode	Voice and 50-kb/s data
Voice signal level	-30 to 0 dBm
Data signal level	-15 to 0 dBm
Input impedance	135 ohms, balanced
Transmit clock frequency	7,200,000±200 Hz
Stability	±60 ppm in free run
Clock output	50,000 Hz square wave
Signal level	±3 volts bipolar
Impedance	75 ohms, balanced
Tranmsitter output	50-kb/s digital signal
Signal level	±3 volts bipolar
Impedance	75 ohms, balanced
RECEIVER	
Input signal	50 kb/s digital
Signal level	±3 volts bipolar, minimum ±0.1 volt
Impedance	75 ohms, balanced
Receiver clock frequency	7,200,000±200 Hz
Stability	Equal to stability of locking frequency
External clock input	50,000 Hz square wave
Signal level	±3 volts bipolar, minimum ±0.1 volt
Impedance	75 ohms, balanced

Table 64-1. Input/ Output Characteristics of Converter CV-3034 (continued)

RECEIVER	
Output voice mode	Nominal 3-kHz voice band
Signal level	-30 to 0 dBm (low level) or -23 to +7 dBm (high level)
Output impedance	600 ohms, balanced
Output hybrid mode	Voice and 50-kb/s data
Voice signal level	-30 to 0 dBm
Data signal level	0±1 dBm
Output impedance	135 ohms, balanced

Table 64-2. Equipment Interface Characteristics

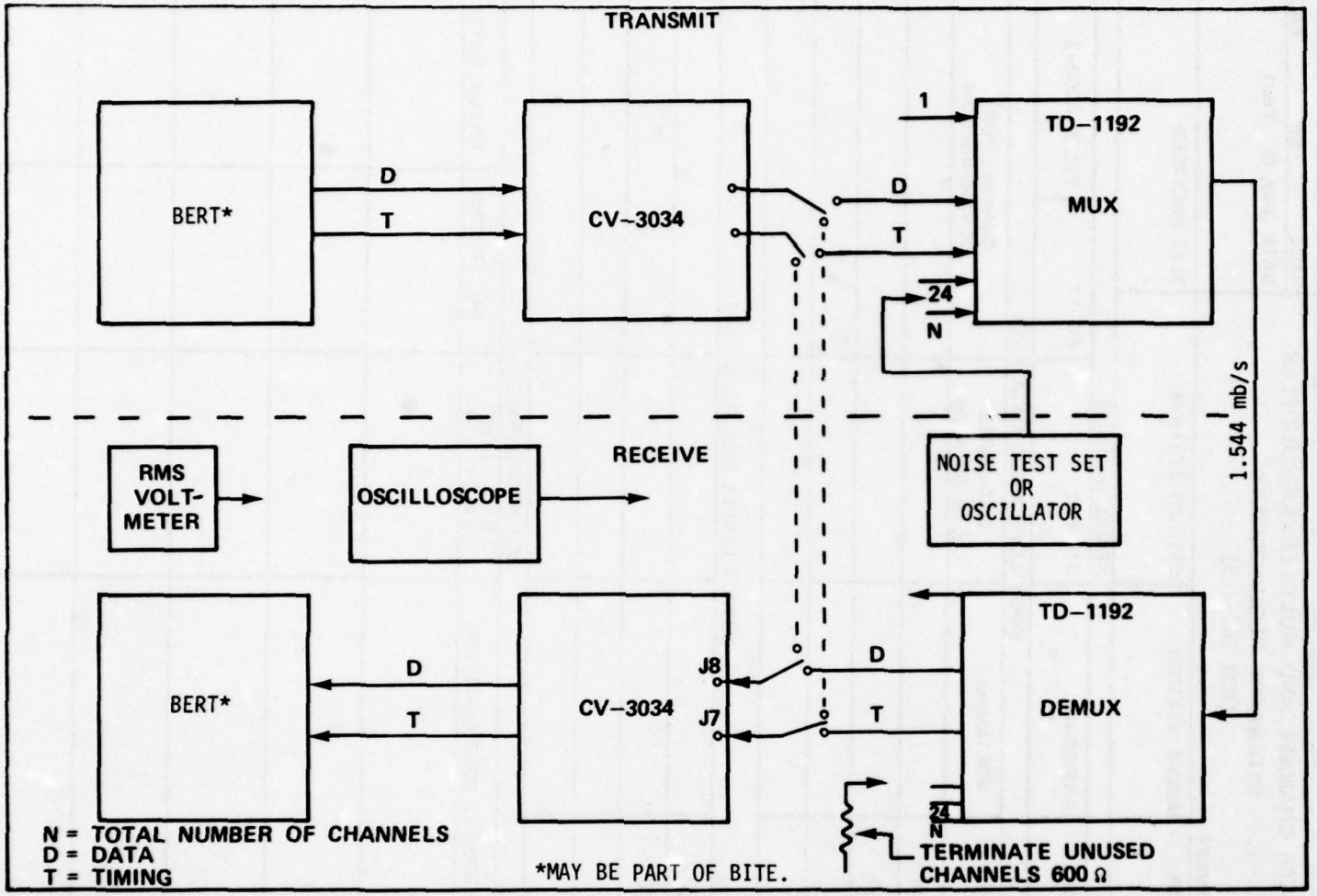
PARAMETER	TD-1192 (AN/FCC-98)	TD-1193	TSEC/KG-81	AN/GSC-24	D2 CHANNEL BANK	D3 CHANNEL BANK
			INPUT			
Waveforms			NRZ data		- -	- -
Voltage level (terminated)						
NRZ	±0.2 to ±7.0 volts	±0.2 to ±7.0 volts	±0.05 to ±3 volts	±0.5 volt minimum	- -	- -
Bipolar	±1.5 to ±3.3 volts	±1.5 to ±3.3 volts	- -	- -	±1.5 to 3 volts	- -
MBS data rate	NA	3.232 mb/s 6.464 mb/s 9.696 mb/s 12.928 mb/s	10 kb/s to 20 mb/s	155 b/s to 10 mb/s	- -	- -
SCBS data rate	192 kb/s	NA	NA	NA	- -	- -
Jitter	12.5%	12.5%	±24%	20%	- -	- -
Impedance						
Bipolar	100Ω nominal (balanced)	100Ω ±10% (balanced)	- -	- -	100Ω nominal	100Ω nominal
NRZ data & timing	78Ω ±10% (balanced)	78Ω ±10% (balanced)	- -	- -	- -	- -
0- to 20-kb/s module	135Ω ±10% (balanced)	- -	- -	- -	- -	- -
VF channel	600Ω ±10% (balanced)	- -	- -	- -	600Ω ±10%	600Ω ±10%
			OUTPUT			
Waveforms			NRZ data		- -	- -
Voltage level						
Bipolar	6±0.6 volts (open circuit)	- -	- -	- -	6 volts ±10%	- -
Logic 1 (low speed)		±6 ±0.6 volts (open circuit) ±3 ±0.3 volts (terminated in 100Ω ±10%)	- -	- -	- -	- -
Logic 0 (low speed)	- -	0±0.01 volt (open circuit) 0±0.005 volt (terminated in 100Ω ±10%)	- -	- -	- -	- -

Table 64-2. Equipment Interface Characteristics (continued)

PARAMETER	TD-1192 (AN/FCC-98)	TD-1193	TSEC/KG-81	AN/GSC-24	D2 CHANNEL BANK	D3 CHANNEL BANK
OUTPUT (continued)						
Voltage level (continued)						
NRZ data & timing	±3 ±0.5 volts (terminated)	- -	- -	- -	- -	- -
	±6 ±1 volts (open circuit)	- -	- -	- -	- -	6±0.6 volts
Logic 1 (low speed)	- -	6±1 volts (open circuit) ±3 ±0.5 volts (terminated in 78Ω ±10%)	- -	- -	- -	- -
Logic 1 (high speed)	- -	±4 ±0.4 volts (open circuit) ±2 ±0.2 volts (terminated in 78Ω ±10%)	- -	- -	- -	- -
Jitter	≤ 2% of data interval ≤ 5% for 50 kb/s	≤ 4% of data interval	- -	10%	- -	- -
SCBS data rate	192 kb/s	NA	NA	NA	- -	- -
MBS data rate	NA	3.232 mb/s 6.464 mb/s 9.696 mb/s 12.928 mb/s	10 kb/s to 20 mb/s	155 b/s to 10 mb/s	- -	- -
Impedance						
Bipolar	100Ω nominal (balanced)	100Ω ±10% (balanced)	- -	- -	100Ω nominal	100Ω nominal
NRZ data & timing	78Ω ±10% (balanced)	78Ω ±10% (balanced)	78Ω ±10% (balanced)	75Ω ±10% (balanced)	- -	- -
0- to 20-kb/s module	135Ω ±10% (balanced)	- -	- -	- -	- -	- -
VF channel	600Ω ±10% (balanced)	- -	- -	- -	- -	- -

Table 64-2. Equipment Interface Characteristics (continued)

PARAMETER	TD-1192 (AN/FCC-98)	TD-1193	TSEC/KG-81	AN/GSC-24	D2 CHANNEL BANK	D3 CHANNEL BANK
OUTPUT (continued)						
Frame sync & acq time						
50 kb/s	Within 50 msec 90% of the time	- -	- -	- -	- -	- -
Any mode	Within 50 msec 90% of the time at a BER of $1x10^{-3}$	Within 131000 consecutive bits 90% of the time	- -	- -	- -	- -
Time to loss of sync	Same as above	Not less than 24 hours at a BER of $1x10^{-2}$	- -	- -	- -	- -
Bit error rate	$\leq 1x10^{-7}$	$\leq 1x10^{-9}$	- -	- -	- -	- -
Ringing						
Bipolar	- -	20% to 40% decaying to 10% or less within 400 msec (overshoot)	- -	- -	- -	- -
NRZ data & timing	$\leq$ 15% of final value (overshoot or undershoot)	$\leq$ 15% of final value (overshoot or undershoot)	- -	- -	- -	- -
Rise & fall times						
Bipolar	80 nsec maximum	$\leq$ 80 nsec	- -	- -	- -	$\geq$ 80 nsec
NRZ data & timing	10% & 90% points less than 100 nsec	10% & 90% points greater than 4 nsec but less than 12 nsec (high speed); less than 100 nsec (low speed)				
Timing						
Initial accuracy	$\pm 3x10^{-5}$ ($25^0 \pm 5^0$ C)	$\pm 3x10^{-5}$ ($25^0 \pm 5^0$ C)	- -	- -	- -	- -
Environmental stability	$\pm 5x10^{-5}$	$\pm 5x10^{-5}$ ($25^0 \pm 5^0$ C)	- -	- -	- -	- -
Long-term stability	$\pm 1x10^{-5}$ per month	$\pm 1x10^{-5}$ per month	- -	- -	- -	±5 Hz



64-11

Figure 64-1. Data channel and multiplex/demultiplex input/output performance test setup.

DATA CHANNEL AND MULTIPLEX/DEMULTIPLEX INTERFACE REQUIREMENTS (CCR 702-1-3) DATA SHEET				PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION		TEST ENGINEER
SERIAL NUMBERS				
CV-3034	AN/GSC-24	TD-1192	KG-81	VICOM 4000-2
INPUT LEVELS AND DATA RATE				
EQUIPMENT	VOLTS/dBm	DATA RATE kb/s OR mb/s	CHANNEL/PORT CONFIGURATION	
CV-3034				
TD-1192				
KG-81				
VICOM 4000-2				
OUTPUT LEVELS AND DATA RATE				
CV-3034				
TD-1192				
KG-81				
VICOM 4000-2				
BER PERFORMANCE				
EQUIPMENT CONFIGURATION		DATA RATE kb/s OR mb/s	NO. ERRORS	ERROR RATE

USACC FORM 657-R
1 MAY 79

Figure 64-2. Data channel and multiplex/demultiplex interface requirements data sheet.

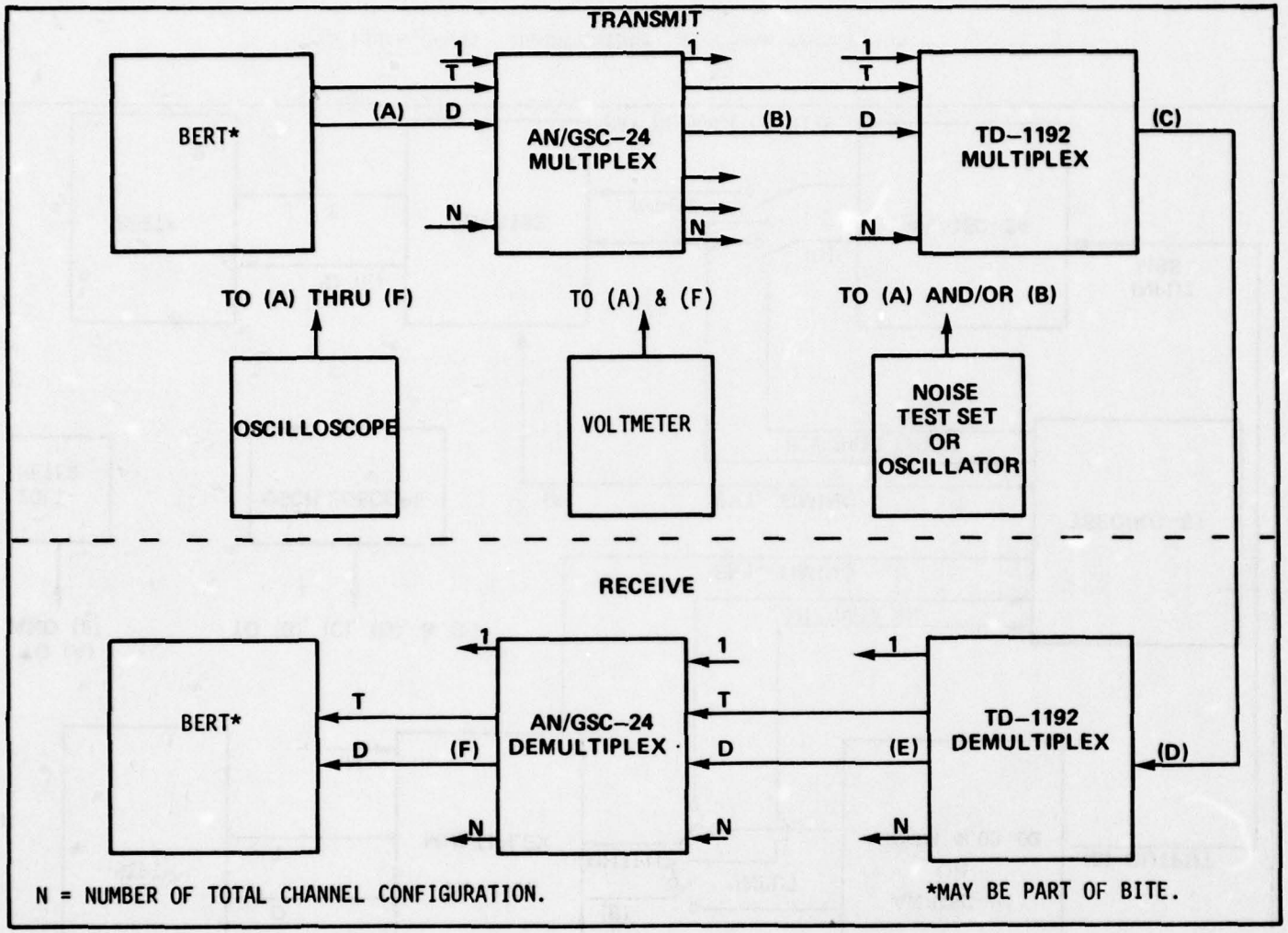
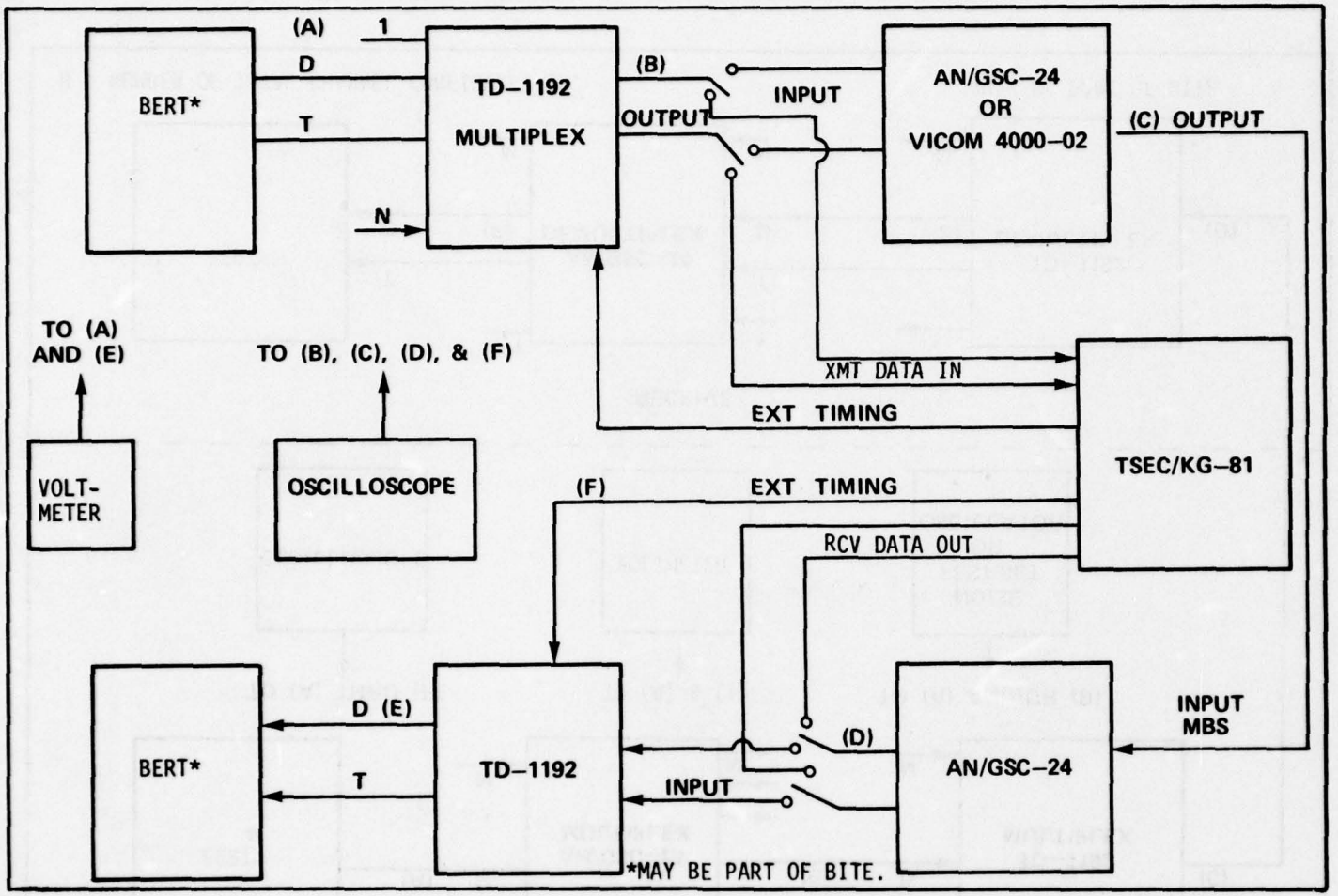


Figure 64-3. Multiplex equipment self-check test setup.



CCP 702-11

64-14

Figure 64-4. Input/output interface test setup.

CHAPTER 65

TEST TONE SIGNAL AND CUSTOMER LEVELS (DT-262)

65-1. GENERAL.

a. The purpose of this test is to measure the levels of selected signals at various test points within a station.

b. The test tone or customer levels may be measured at TP-2, TP-3, TP-10, and TP-11 as shown in chapter 1. If the specifications are not met at these test points, a complete alinement of the equipment may be required.

c. This test may be performed on a link basis or with the multiplex/demultiplex in a loop configuration. The specifications for the AN/FCC-98 contained in paragraph 65-2, below, are with a multiplex looped. During field testing, however, the test would normally be performed on a link basis and the results compared to the military standard or DCA link specifications.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be performed by installer or quality assurance personnel during onsite test activities as directed.

65-2. SPECIFICATIONS.

a. The audio test tone of the TD-1192 (AN/FCC-98) for alinement and testing of voice bandwidth channels shall be 0 dBm0, 1020-Hz sine wave ±5 Hz. (CCC-74047)

b. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

65-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Oscilloscope.

65-4. TEST PROCEDURES.

a. Record the equipment reference level (TLP), the test tone level, and the absolute tone level for each applicable test point on figure 65-1 (USACC Form 658-R). If additional space is required, use figure 3-7 (DD Form 2091).

b. Connect the test equipment as shown in figure 65-2 for local loop configuration or figure 65-3 for a link configuration. Allow approximately 30 minmutes for warmup and stabilization. As shown in figue 65-2, the test tone may be inserted at the circuit patch bay, the voice frequency patch bay, or directly into the multiplex channel. If performed as part of a local multiplex alinement, it would normally be inserted directly into the channel. For most other test activities, the test point would be at the circuit patch bay.

c. Ensure that the voice frequency channel cards are configured for voice input signals. The nominal test tone level used in the DCS is -10 dBm0; however, the input levels for the AN/FCC-98 have been standardized at 0 or -16 dBm. The channel output has also been standardized at 0 or 7 dBm. Also on the AN/FCC-98, the input/output channel cards may be changed to accommodate either voice or data signals.

d. At the transmit end, establish a 1020 Hz, -10 dBm0 test tone reference level from the transmission measuring set or separate oscillator. Terminate the output into a precision 600-ohm load. Measure the output signal level with the voltmeter and adjust the output for -10 dBm0. If performing the test on the AN/FCC-98 multiplex, adjust the output for 0 dBm0. During the steps that follow, do not readjust the output amplitude or the oscillator frequency.

e. Remove the 600-ohm precision terminating load and connect the outpupt to the channel to be tested (fig. 65-2). Measure and record this as the input power level. The input power level may differ from the reference established in subparagraph d, above, due to the fact that the channel input impedance may not be exactly 600 ohms. If a significant level difference exists, it is possible that the impedance is incorrect, the channel is double terminated, or other impedance irregularities exist in the channel input circuits.

f. At the transmit end, measure the test tone levels at TP-1, TP-2, and TP-3 by bridging the voltmeter at the test point. Using the oscilloscope, measure the peak-to-peak voltage of the PCM signal at the remaining test points.

g. At the receive end, terminate the channel under test into the voltmeter (600 ohms). Measure the test tone levels at TP-10, TP-11, and TP-12 if applicable. Record the results on the data sheet. Using the oscilloscope, measure and record the PCM levels at TP-7 and TP-9. Refer to figures 1-1 and 1-2 for the test point designations.

h. Repeat the above procedure for all other voice frequency channels and then reverse the direction of transmission and repeat the tests for all channels in the reverse direction.

i. If level errors exist, identify the source of the problem and if necessary aline the multiplex according to the equipment technical manual.

j. If the system is in traffic, it may be necessary to first test all spare channels and then temporarily patch the inservice channels to one of the spares. Also if in traffic, measure and record the levels of all customer provided signals.

k. If any of the TD-1192 channels are configured for data input rather than voice frequency, measure the data level with the oscilloscope and modify the data sheet to accommodate the various test requirements.

65-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the data for completeness and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

DATA SHEET	TEST TONE AND CUSTOMER LEVELS (CCR 702-1-3)								PAGE OF PAGES				
									DATE (DAY, MO., YEAR)				
DCS LINK NO.		STATION UNDER TEST			DISTANT STATION				TEST ENGINEERS SIGNATURE				
TYPE SIGNAL		TEST POINT AND DESIGN LEVEL											
TEST TONE	CUSTOMER LEVEL TRAFFIC	TP-1 (dBm)	TP-2 (dBm)	TP-3 (dBm)	TP-4 (VPP)	TP-5	TP-6 (VPP)	TP-7 (VPP)	TP-8	TP-9 (VPP)	TP-10 (dBm)	TP-11 (dBm)	TP-12 (dBm)

USACC FORM 658-R
1 MAY 79

Figure 65-1. Test tone and customer levels data sheet.

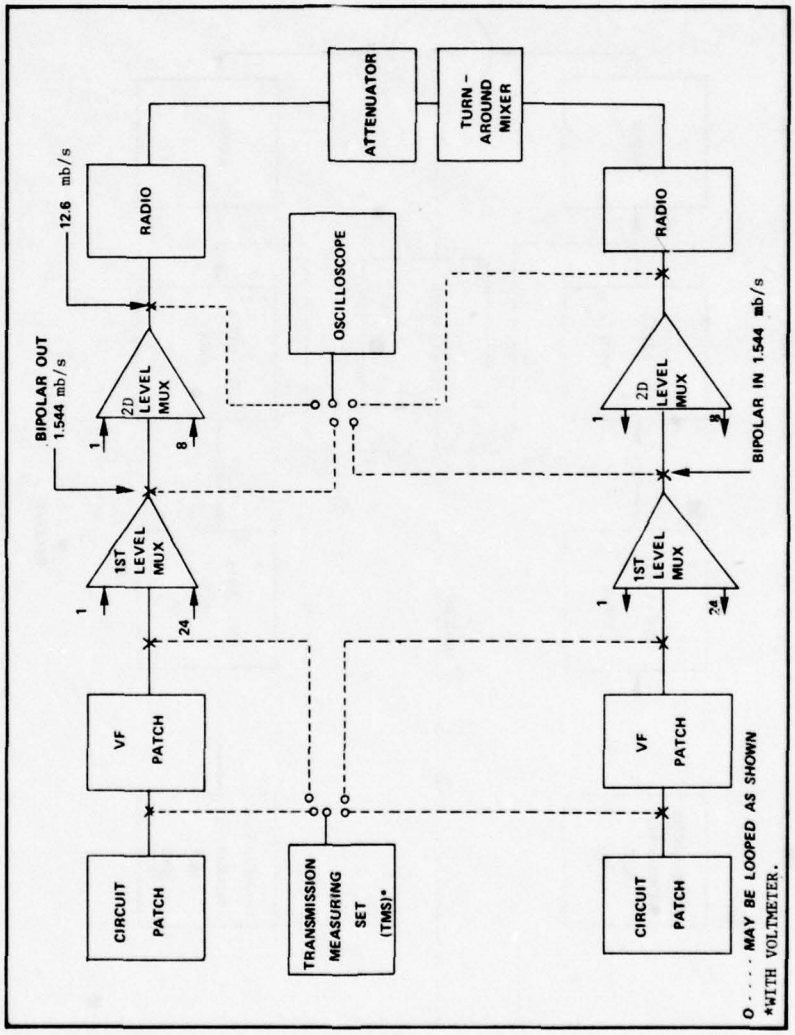


Figure 65-2. Typical test tone level (back-to-back) test setup.

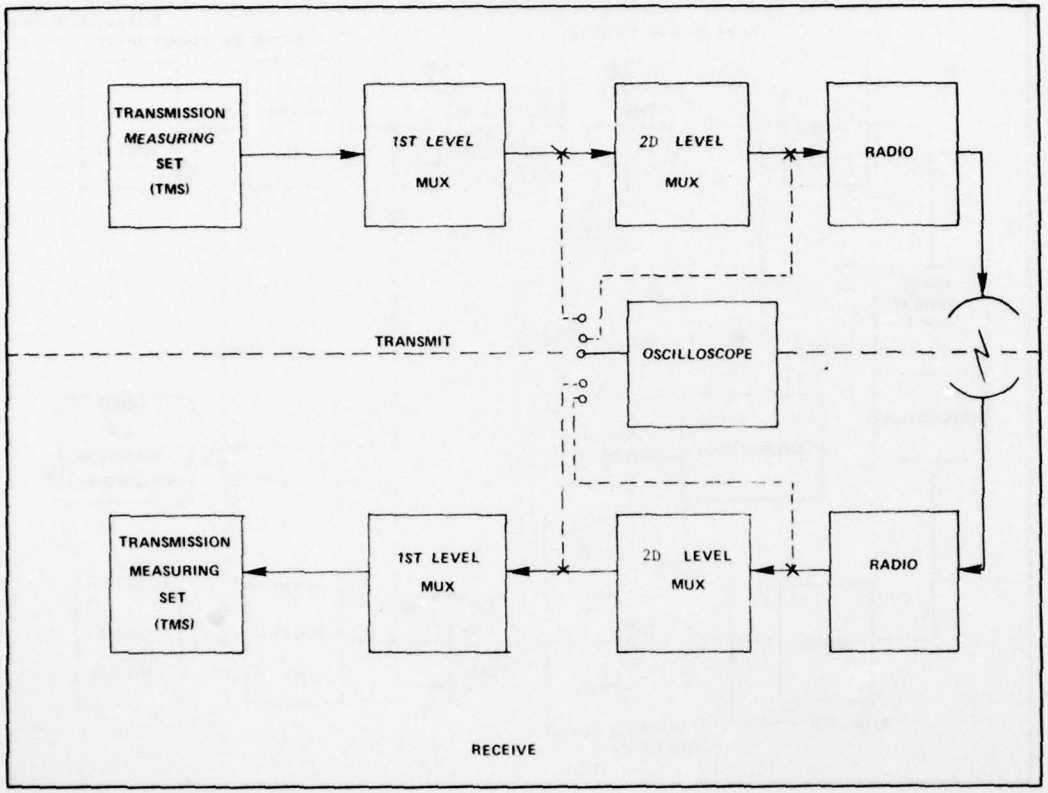


Figure 65-3. Test tone and customer levels (AN/FRC-162 and VICOM 4000-2 system) (link) test setup.

CHAPTER 66

INSERTION LOSS VS FREQUENCY (AUTOMATIC METHOD) (DT-263)

66-1. GENERAL.

a. The purpose of this test is to determine the frequency response versus loss characteristics of the multiplex/demultiplex equipment.

b. This test may be performed with a multiplex loop or on a link basis. If testing the multiplex equipment for compliance with the equipment specification, it will be necessary to perform the test with a multiplex loop. However, if the testing is to determine the end-to-end performance of all multiplex, radio, and associated equipment, the test should be performed on a link basis.

c. The voice channel frequency response versus loss measurements on an end-to-end basis will normally be made at the circuit patch bay. In some cases, conditioning equipment installed between the circuit patch bay and the VFPB may require that the test be performed at the VFPB. If conditioning equipment is installed to equalize the channel performance on a circuit basis and the test is performed through the conditioning equipment, this equipment should be adjusted according to the circuit parameters for best performance.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

66-2. SPECIFICATIONS.

a. As a design objective, the insertion loss versus frequency characteristics referenced to 1000 Hz of a long haul TDM/PCM reference voice bandwidth link shall not exceed the values given in table 66-1. (MIL-STD-188-100)

b. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) Each channel shall transmit voice frequencies from a voice frequency input to a voice frequency output terminal with deviation relative to 0 dBm0, 1020±5 Hz test tone as indicated in table 66-1 and as shown in figure 66-1.

(2) A 0 dBm0 test tone level at any frequency between 300 and 3000 Hz injected in any voice frequency channel transversing six consecutive modulating/multiplexing and demodulating/demultiplexing functions using two or more multiplex terminals in a tandem configuration shall not exhibit a deviation greater than ±3 dB relative to 1020 Hz.

c. As a design objective for the AN/FRC-162 and VICOM 4000-2 system, the insertion loss versus frequency referenced to a 1000-Hz test tone shall not exceed the values shown in table 66-1.

d. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

66-3. TEST EQUIPMENT REQUIRED.

a. Delay measuring set or voice frequency sweep oscillator.

b. X-Y recorder.

c. 600-ohm precision resistors.

d. Transmission measuring set.

e. Voltmeter.

f. Frequency counter.

g. Oscilloscope.

h. Logarithmic/linear amplifier.

i. Balanced/unbalanced transformer.

66-4. TEST PROCEDURES. This test may be performed using a local multiplex/demultiplex loop, an RF loop, or over the link with a number of multiplexers and demultiplexers operating in tandem. The method used will determine the specification with which the test results should be compared.

a. At the transmit and receive ends, determine if the channel input/output has been configured for balanced or unbalanced operation, especially if the test tone is inserted directly into the channel bank.

b. At the transmit end, calibrate the delay measuring set or voice frequency sweep oscillator by connecting the 600-ohm output into a 600-ohm precision resistor as shown in figure 66-2. Allow approximately 30 minutes for warmup and stabilization.

NOTE: If the delay measuring set or voice frequency oscillator has a 600-ohm balanced output, the balanced/unbalanced transformer may be omitted. If the transformer is used, its frequency characteristics should be determined before proceeding with the test.

c. Adjust the 600-ohm output of the delay measuring set or voice frequency sweep oscillator to 0 dBm0 at 1020±5 Hz if the test is being performed at the circuit patch bay. Adjust the output to correspond to the TLP design level if performed at other TLP's.

NOTE: If the test is being performed on an operational system, it may be desirable to use a -10 dBm0 test tone to preclude the possibility of interference with system traffic. However, if the channel input has been designed and is strapped for 0 dBm such as the AN/FCC-98, then a 0-dBm tone should be used.

d. Set the sweep of the delay measuring set or voice frequency sweep oscillator to a range of 100 Hz to 4 kHz for the AN/FRC-162 and VICOM 4000-2 system and to 4600 Hz for the AN/FCC-98 at a rate of approximately 4 sweeps per minute. Observe the voltmeter as the delay measuring set sweeps across the frequency range. If the test equipment is operating properly, the voltmeter reading should not vary more than ±0.15 dB throughout the sweep range. Return the delay measuring set to the 1020-Hz setting and connect it to the input of the voice channel/equipment as shown in figure 66-2.

e. If performing the test in a local loop, connect the output of the CY-104, TD-1192, TD-1193, or VICOM 4000-2 as shown in figure 66-3. At some installations, the multiplex/demultiplex input/output may be wired to a patch panel which can be used for looping the signal. At some locations, the back-to-back patch may have to be made at the equipment. In any case, verify the input/output level using the oscilloscope.

f. At the receive end, calibrate the delay measuring set or voice frequency sweep oscillator to cover the frequency range as stated in subparagraph d, above. Refer to figure 66-2 and perform the following steps.

(1) Connect the oscillator output through the step attenuator to the balanced/unbalanced transformer. Terminate the secondary of the transformer into the delay measuring set (for 600-ohm operation). Adjust the oscillator output to 1020±5 Hz at 0 dBm0 as read on the frequency counter and voltmeter.

(2) Connect the remaining equipment as shown in figure 66-2 for receive end calibration.

NOTE: If the test is performed at the 7060 test panel of the CY-104, as part of a lineup procedure, a level of -20 dBm0 should be used.

(3) Using the delay measuring set frequency counter or the external counter, calibrate the X-axis of the recorder between 100 and 4600 Hz by manually varying the carrier frequency and adjusting the recorder controls. Record the data on figure 3-4 (DD Form 2094).

(4) Switch the delay measuring set to the receive position and calibrate the Y-axis of the recorder between approximately +5 and -5 dBm0 by varying the

step attenuator and adjusting the logarithmic/linear amplifier and recorder controls as necessary to establish the gain/loss calibration. The step attenuator should be adjusted in 1-dB steps over the expected level of deviation.

(5) Once the recorder has been calibrated, connect the delay measuring set input to the channel (receive) under test as shown in figure 66-2 or 66-3.

g. At the transmit end, set the delay measuring set to 1020 Hz at 0 dBm0. At the receive end, measure the 0 dBm0 received tone. The receive level should not deviate more than ±0.5 dB from the level being transmitted. At the transmit end, place the delay measuring set in the automatic sweep mode. Set the output frequency to the low end of the frequency spectrum. Energize the delay measuring set sweep. As it slowly sweeps across the selected frequency range, observe the output level on the voltmeter. If a significant difference exists in the output level (1 dB) compared to the level at 1020 Hz, perform the manual sweep test (DT-264).

h. At the transmit end, reduce the delay measuring set frequency to 100 Hz or until the receive recorder goes off scale. At the receive end, lower the recorder pen onto figure 3-4 (DD Form 2094).

i. At the transmit end, turn on the delay measuring set sweep and allow the sweep to continue until the receive recorder pen goes off scale or at least to the highest frequency specified for the equipment. Turn off the transmit delay measuring set sweep and raise the receive pen of the X-Y recorder.

j. On some TDM/PCM equipment it may be necessary to use a holding tone while the channel response is being performed. If this type system is encountered, proceed as follows:

(1) At the transmit end, set the frequency of the fixed oscillator to 1020 Hz (fig. 66-4). Adjust the output level of the fixed oscillator and delay measuring set to provide a composite level of 0 or -10 dBm0 for systems carrying operational traffic.

(2) With the delay measuring set, sweep the frequency range as outlined in table 66-1. At the receive end, lower the recorder pen on figure 3-4 (DD Form 2094) and allow the recorder to sweep the required frequency range.

NOTE: A sharp discontinuity may appear at the 1020-Hz frequency as the delay measuring set sweeps through this frequency. If other discontinuities are noted, it may be necessary to examine the channel with a wave analyzer.

k. An alternate test configuration is shown in figure 66-5. This test is described in detail in a separate document still to be published. The key to this system is the programmable calculator which can automatically collect, plot, and analyze the test data based on a preprogrammed cassette tape.

l. Repeat the above procedures for all channels.

66-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

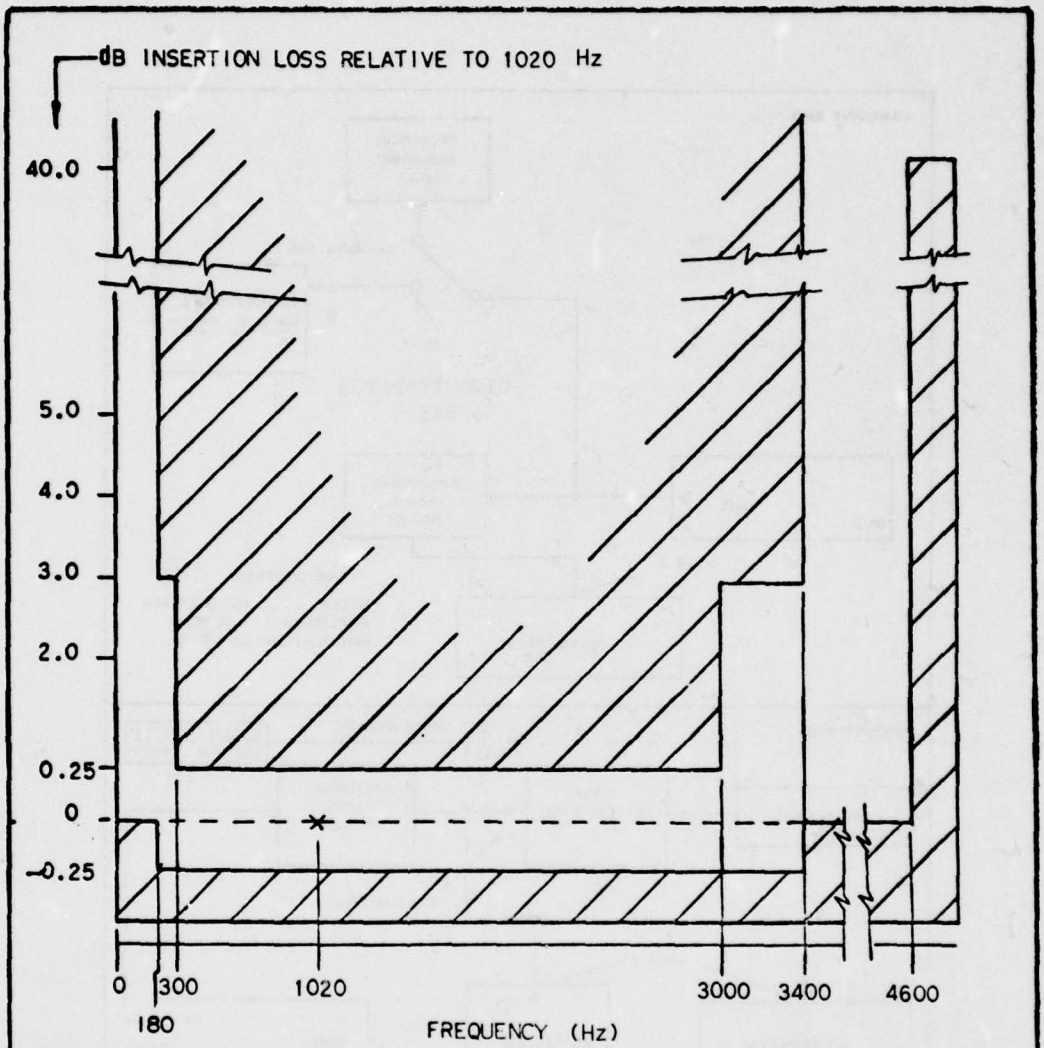
b. Remove all test equipment and restore the system to its normal configuration.

c. If the system fails to meet specifications, notify the responsible activity of required corrective actions.

Table 66-1. Insertion Loss and Gain vs Frequency

FREQUENCY (Hz)	INSERTION LOSS AND GAIN (dB)
LONG HAUL TDM/PCM Reference: MIL-STD-188-100	
Below 200	Greater than zero
200 to 300	Greater than -0.7
300 to 400	-0.7 to 3.0
400 to 600	-0.7 to 1.5
600 to 2400	-0.7 to 0.7
2400 to 3000	-0.7 to 1.5
3000 to 3400	-0.7 to 3.0
3400 to 4600	Greater than -0.7
Above 4600	Greater than 40.0
TD-1192 (AN/FCC-98) Reference: CCC 74047	
Below 180	Greater than zero
180 to 300	3 to -0.25
300 to 3000	±0.25
3000 to 3400	3 to -0.25
3400 to 4600	Greater than zero
Above 4600	Greater than 40
AN/FRC-162 AND VICOM 4000-2 SYSTEM DESIGN OBJECTIVE	
Below 200	Greater than zero
200 to 300	Greater than -0.7
300 to 400	-0.7 to 3.0
400 to 600	-0.7 to 1.5
600 to 2400	-0.7 to 0.7
2400 to 3000	-0.7 to 1.5
3000 to 3400	-0.7 to 3.0

NOTE: Loss is indicated by (+); gain by (-).



NOTES: 1. TO APPLY THESE LIMITS, THE CURVE OF THE VARIATIONS OF INSERTION LOSS AS A FUNCTION OF FREQUENCY SHOULD BE NORMALIZED TO PASS THROUGH 0 dB AT A FREQUENCY OF 1020 Hz. THE CURVE SHOULD THEN LIE WHOLLY BETWEEN THE UPPER AND LOWER HATCHED LINES.

2. THE LIMITS ARE FOR THE INSERTION LOSS AS MEASURED BETWEEN THE AUDIO INPUT AND AUDIO OUTPUT.

Figure 66-1. Insertion loss vs frequency limits (TD-1192).

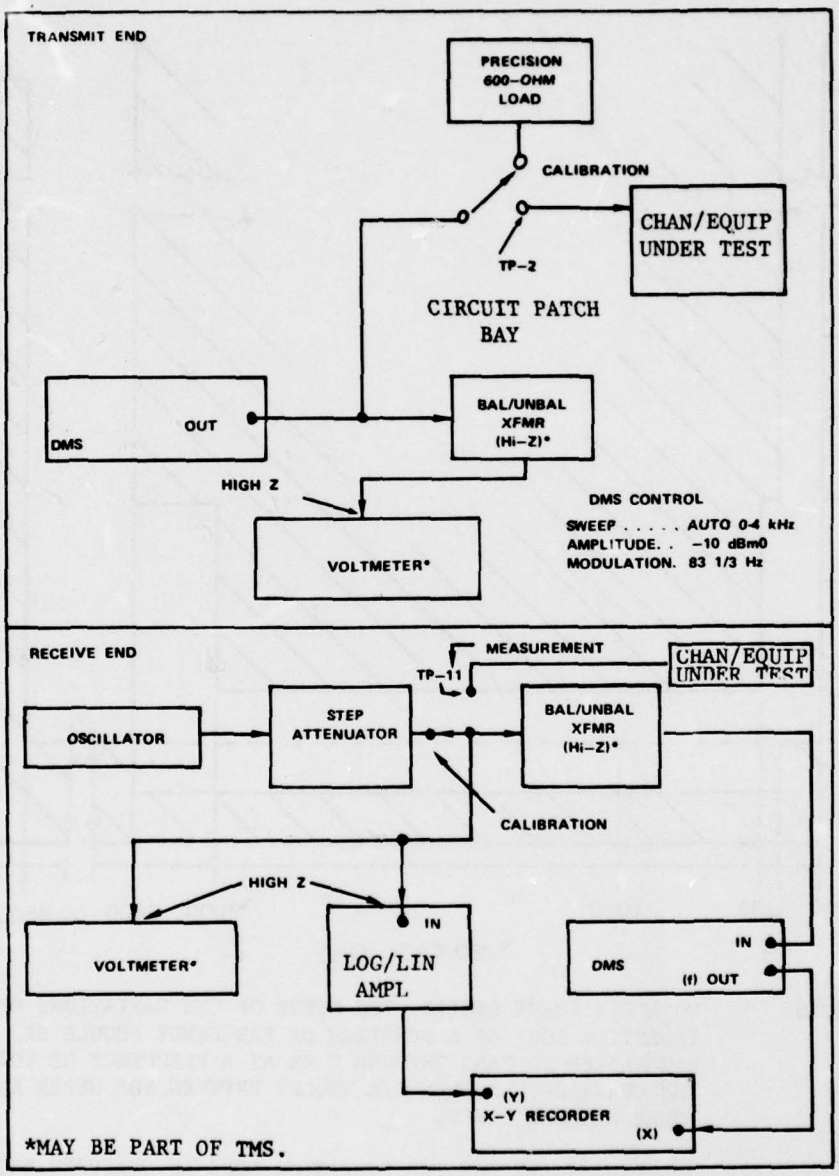


Figure 66-2. Insertion loss vs frequency (automatic method) (calibration).

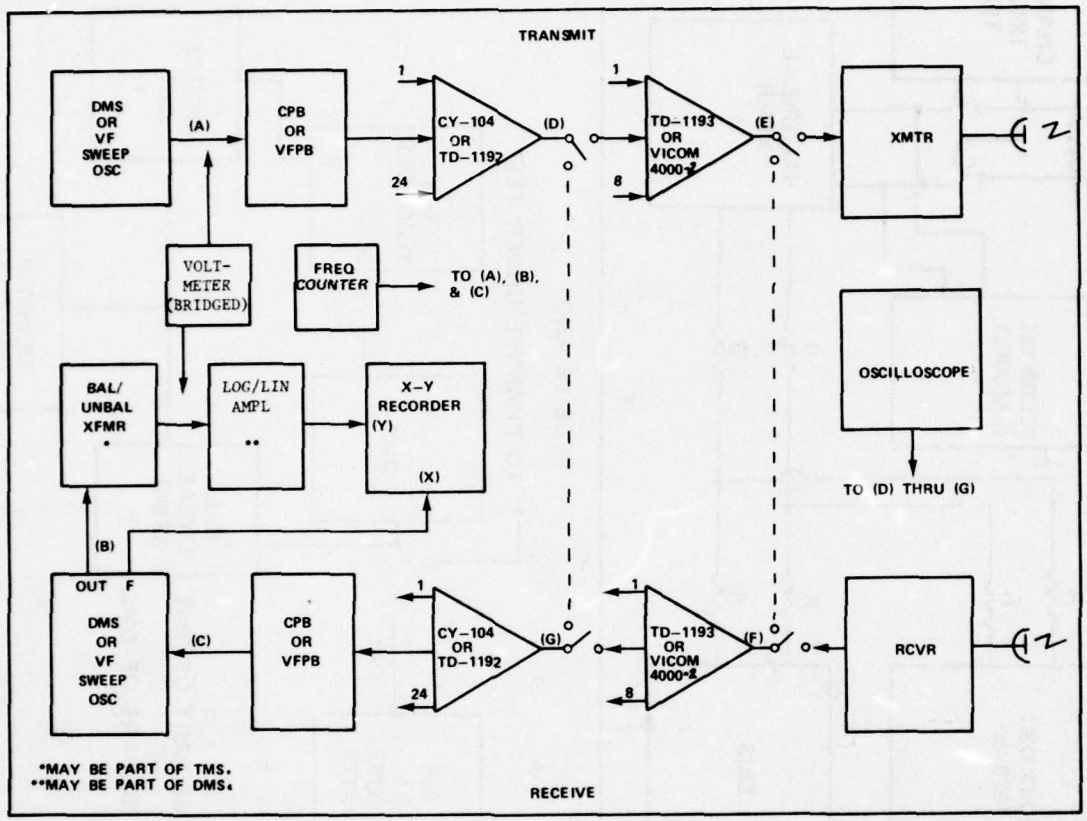


Figure 66-3. Insertion loss vs frequency (TSEC/CY-104, TD-1192, TD-1193, or VICOM 4000-2) test setup.

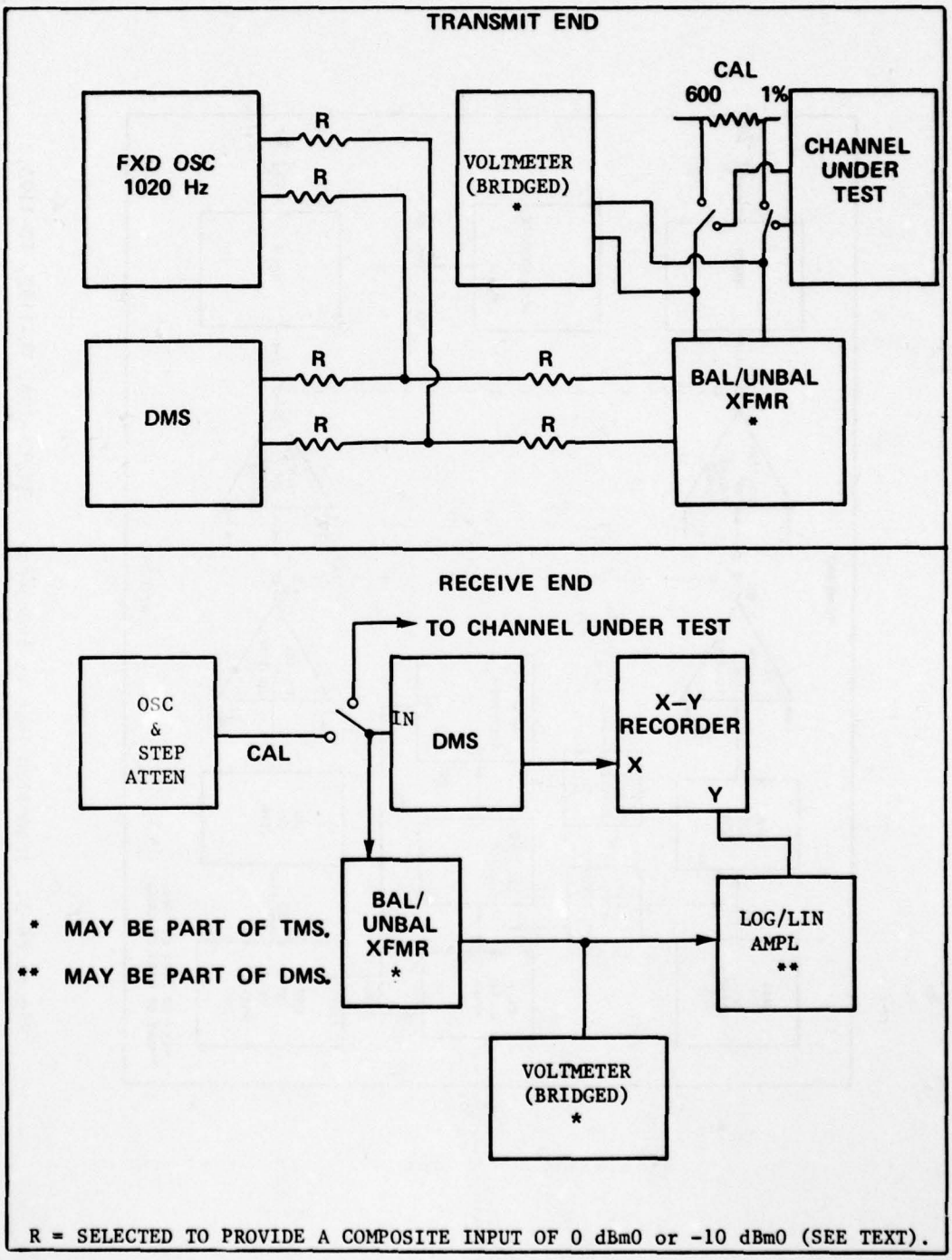


Figure 66-4. Insertion loss vs frequency (TDM/PCM) test setup.

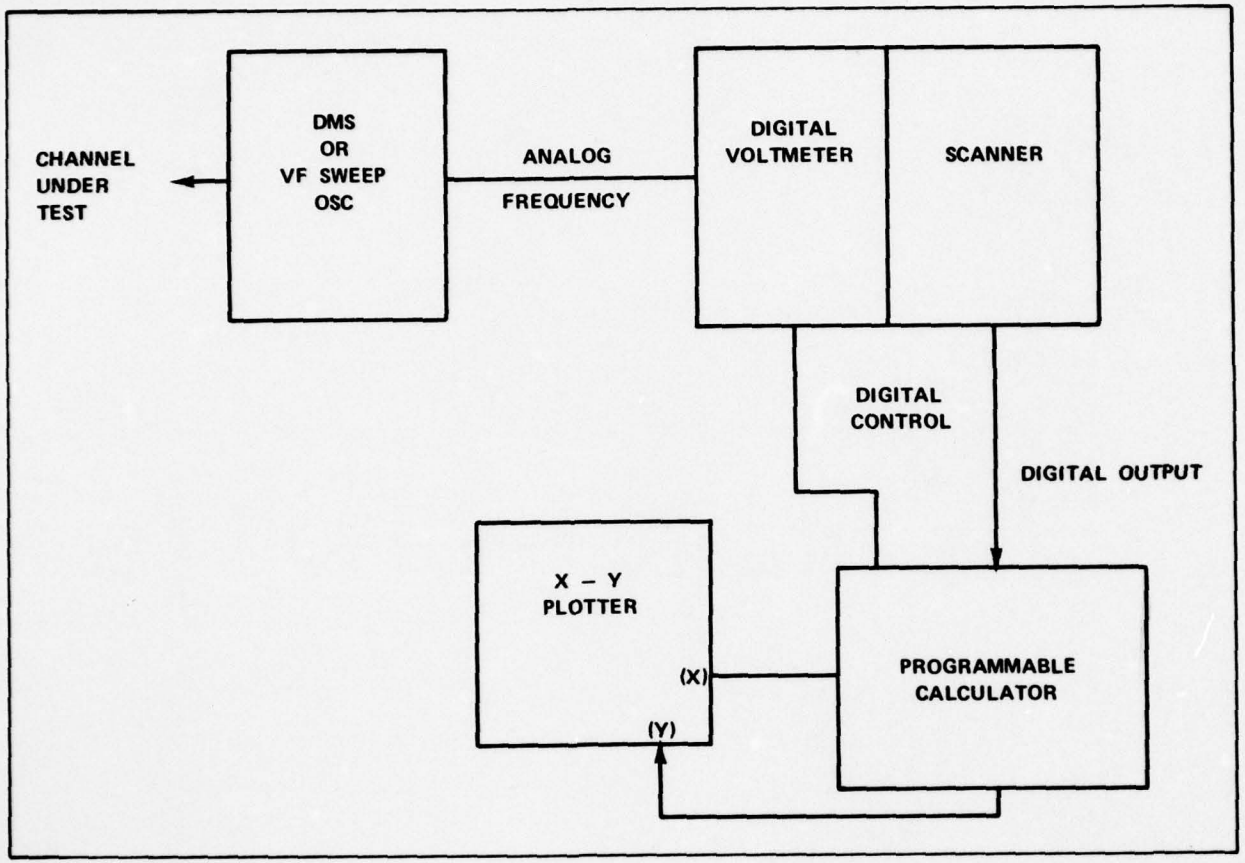


Figure 66-5. Insertion loss vs frequency (automatic method) test setup.

CHAPTER 67

VOICE CHANNEL FREQUENCY RESPONSE (MANUAL METHOD) (DT-264)

67-1. GENERAL.

a. The purpose of this test is to determine (point-by-point measurements) the amplitude versus frequency response of the individual voice frequency channels.

b. This test may be performed with a multiplex loop or on a link basis. If testing the multiplex equipment for compliance with the equipment specifications, it will be necessary to perform the test with a multiplex loop, except as outlined in paragraph 67-2b(2). However, if the testing is to determine the end-to-end performance of all multiplex, radio, and associated equipment, the test would normally be performed on a link basis.

c. The voice channel frequency response versus loss characteristics on an end-to-end basis will normally be made at the circuit patch bay. In some cases, conditioning equipment installed between the circuit patch bay and VFPB may require that the test be performed at the VFPB. If conditioning equipment is installed to equalize the channel performance on a circuit basis and the test is performed through the conditioning equipment, this equipment should be adjusted according to the circuit parameters for best performance.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

67-2. SPECIFICATIONS.

a. As a design objective, the insertion loss versus frequency characteristics referenced to 1000 Hz of a long haul TDM/PCM reference voice bandwidth link shall not exceed the values given in table 66-1. (MIL-STD-188-100)

b. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) Each channel shall transmit voice frequencies from a voice frequency input to a voice frequency output terminal with deviation relative to 0 dBm0, 1020±5 Hz test tone as indicated in table 66-1 and as shown in figure 67-1.

(2) A 0-dBm0 test tone level at any frequency between 300 and 3000 Hz injected in any voice frequency channel transversing six consecutive modulating/multiplexing and demodulating/demultiplexing functions using two or more

multiplex terminals in a tandem configuration shall not exhibit a deviation greater than ±3 dB relative to 1020 Hz.

c. As a design objective for the AN/FRC-162 and VICOM 4000-2 system, the insertion loss versus frequency referenced to a 1000-Hz test tone shall not exceed the values shown in table 66-1.

d. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

67-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Voltmeter.

c. Balanced/unbalanced transformer (if required).

d. Frequency selective voltmeter.

e. Frequency counter.

f. Oscilloscope.

g. Precision resistors.

67-4. TEST PROCEDURES.

a. Complete the top portion of figure 16-4 (DD From 2095). Modify the frequency column of the form as required to correspond with the system under test.

b. Initially, connect the test equipment at the transmit end for calibration as shown in figure 67-1. Allow approximately 30 minutes for warmup and stabilization.

c. At the transmit end, calibrate the audio oscillator of the transmission measuring set for 0 dBm0 at 1020±5 Hz using an external precision 600-ohm termination. Ensure that the calibration is accomplished in the balanced position. Omit the balanced/unbalanced transformer if the oscillator has provisions for a 600-ohm balanced output (fig. 67-1). Set the output for -10 dBm if the test is to be performed on an operational system carrying traffic. Use a 0-dBm0 tone if testing the AN/FCC-98 to specifications.

d. Manually sweep the oscillator frequency over the range specified in table 66-1. Observe the output level on the voltmeter. If the output level is constant over the required frequency range (±0.15 dB), then the oscillator accuracy has been confirmed and the test can proceed as shown in figure 67-2.

e. At the receive end, connect the AC voltmeter and the frequency counter as shown in figure 67-1, to the voice frequency channel output at the circuit patch bay or other designated test points.

f. At the transmit end, insert a 1020-Hz, 0-dBm0 tone into the channel under test or -10 dBm0 for those systems that are in traffic.

g. At the receive end, connect the AC voltmeter and frequency counter to the channel under test as shown in figure 67-1. Another method would be to use an audio frequency selective voltmeter or wave analyzer as shown in figure 67-2. With the 1020-Hz test tone being transmitted, the receive tone should be within the specifications contained in table 66-1. If the levels are out of tolerance, make measurements at other test points within the system and realine the multiplex if necessary.

h. At the transmit end, adjust the oscillator output frequency in sequence to those frequencies shown in table 66-1. At the receive end, measure the level and frequency of each transmitted signal and record this data on the data sheet. Additional frequencies may be selected by the Team chief.

i. Perform the test at a number of discrete frequencies so that a smooth curve can be plotted on figure 3-4 (DD Form 2094). Additionally, the upper and lower frequency limits used for the test should provide a sharp rolloff relative to the 1020-Hz test tone. For a graph of insertion loss versus frequency limits see figure 66-1.

j. If the transmit test tone level drops as the tone is inserted into the channel, adjust the level to the 0-dBm0 reference at each frequency.

k. If the test is performed over the link, take the data at both ends of the link. Plot and record the data using the same scale units.

l. Repeat the above test on all voice frequency channels.

m. If it becomes necessary to insert a holding tone on some PCM/TDM multiplex units while the frequency response test is being performed, proceed with the test as follows:

(1) Connect the test equipment as shown in figure 67-3.

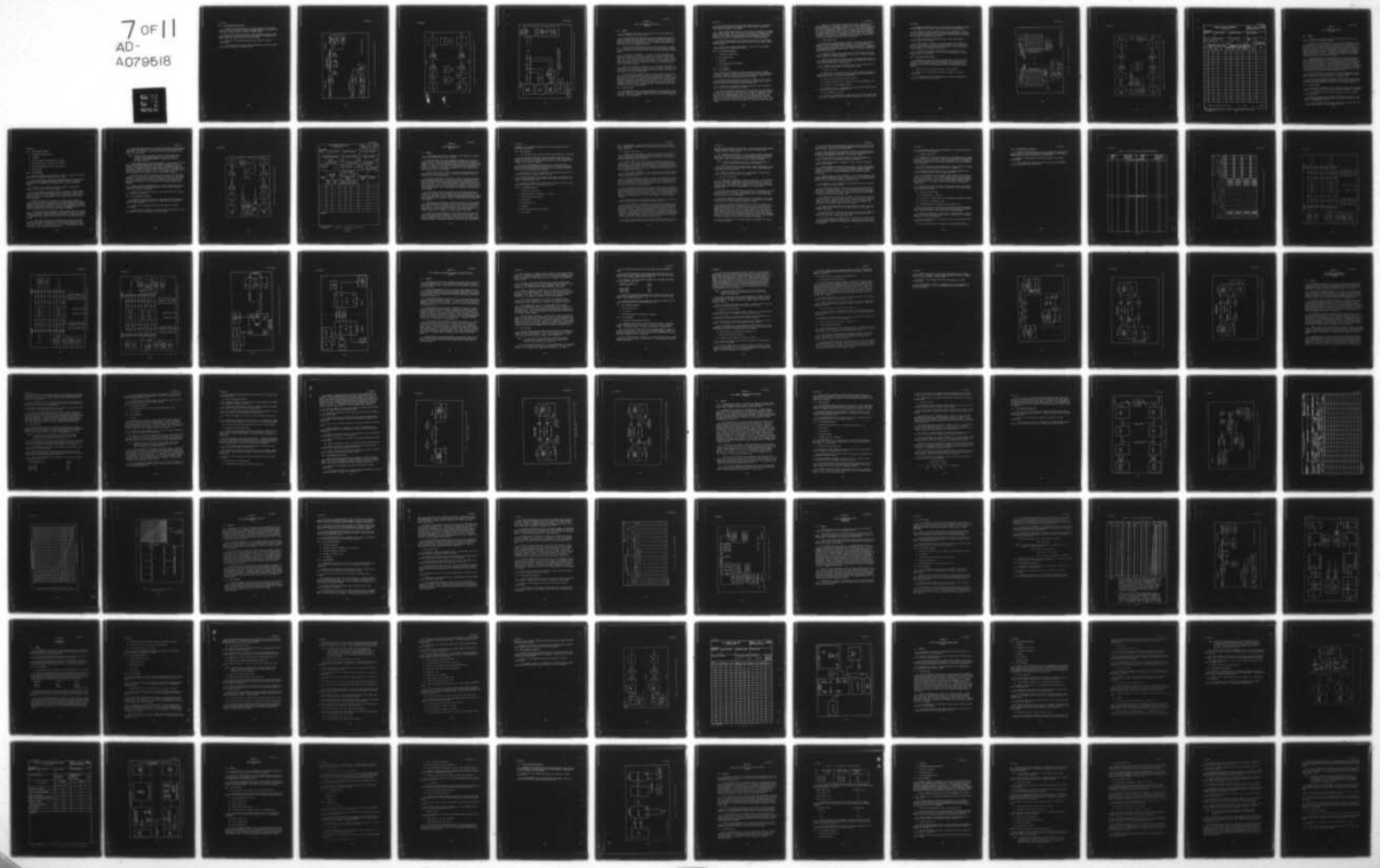
(2) Set the frequency of the fixed oscillator to 1020 Hz. This will be used as the holding tone.

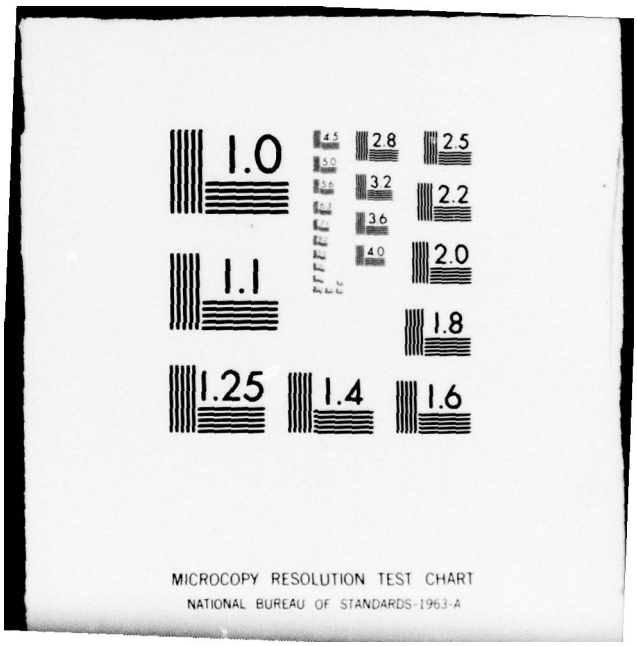
(3) Adjust the output of the oscillators to provide a composite test tone of 0 or -10 dBm0 into the channel as outlined in subparagraph c, above.

(4) Perform the procedures outlined in subparagraphs a through m, above.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

7 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

67-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheets and if the output levels of the 1st and 2d level multiplex are measured, enter the results in the supergroup and group columns of figure 16-4 (DD Form 2095).

b. Plot all test results on figure 3-4 (DD Form 2094) and prepare a template, based on the specifications, that can be used for analyzing the data. Summarize the test results on figure 3-7 (DD Form 2091).

c. Remove all test equipment and restore the system to its normal configuration.

d. If the system fails to meet specified requirements, notify the responsible activity of required corrective actions.

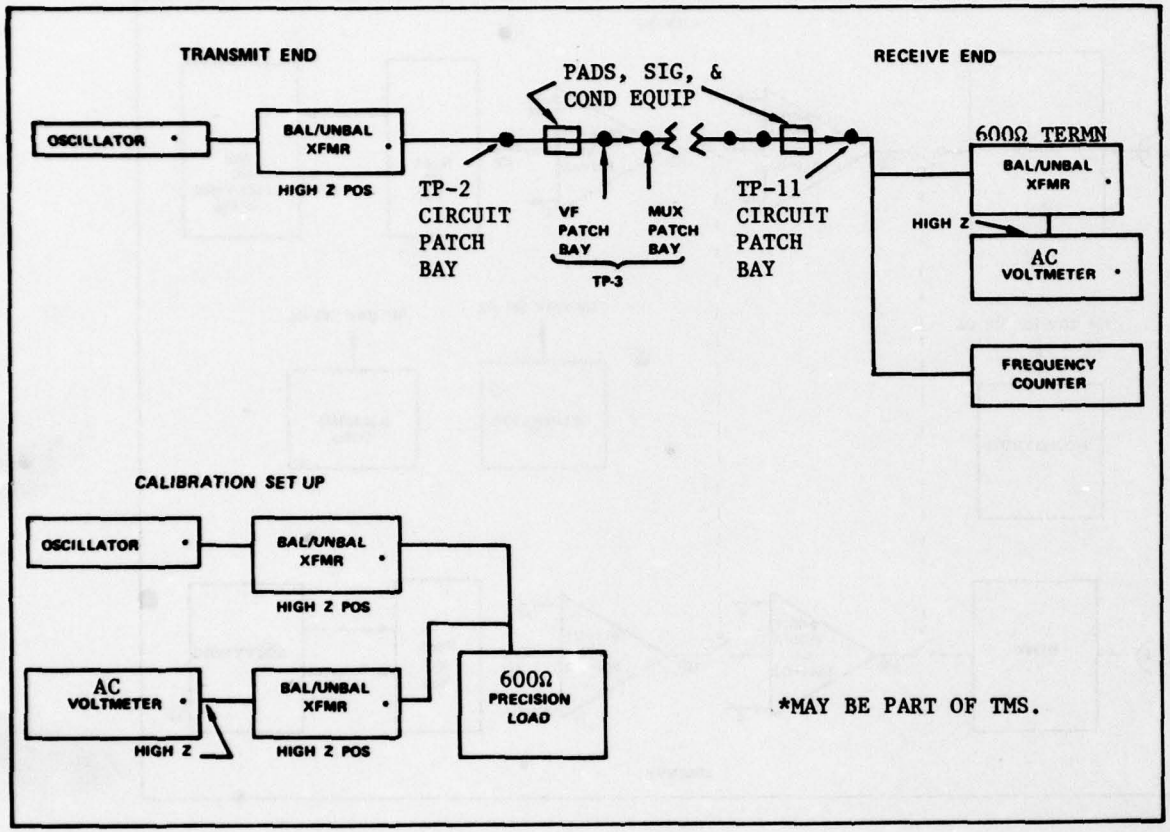


Figure 67-1. Voice channel frequency response (calibration).

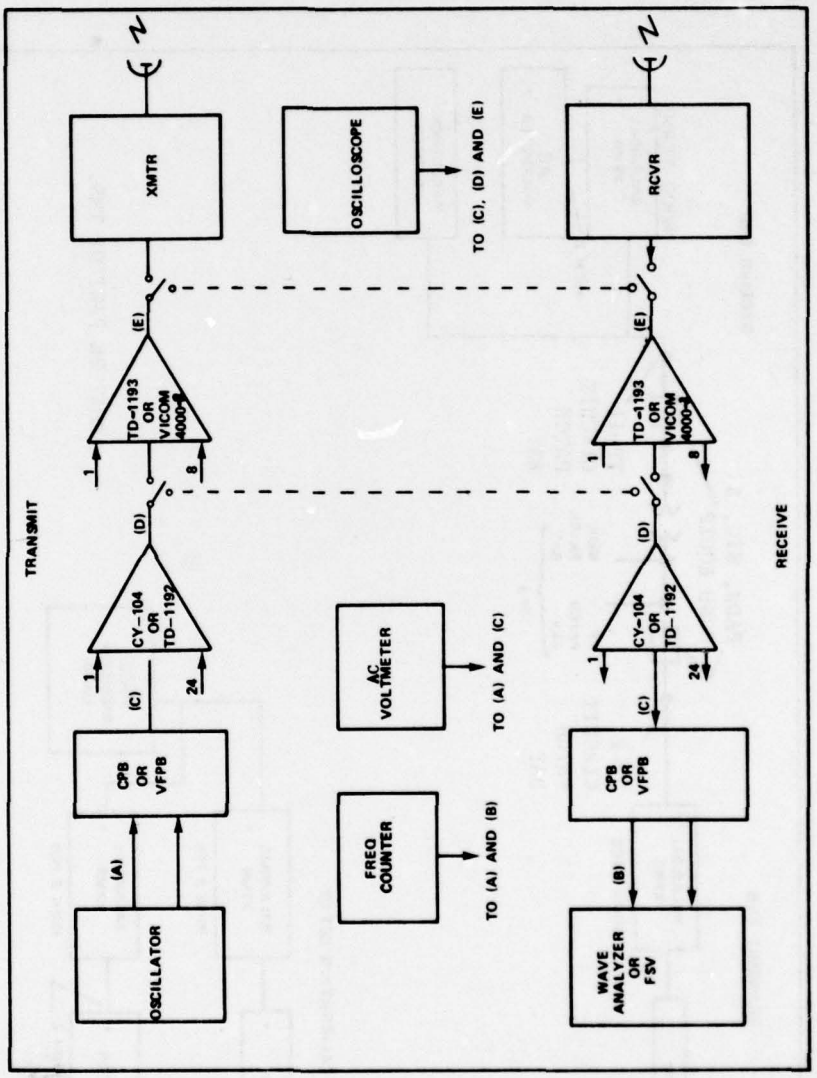
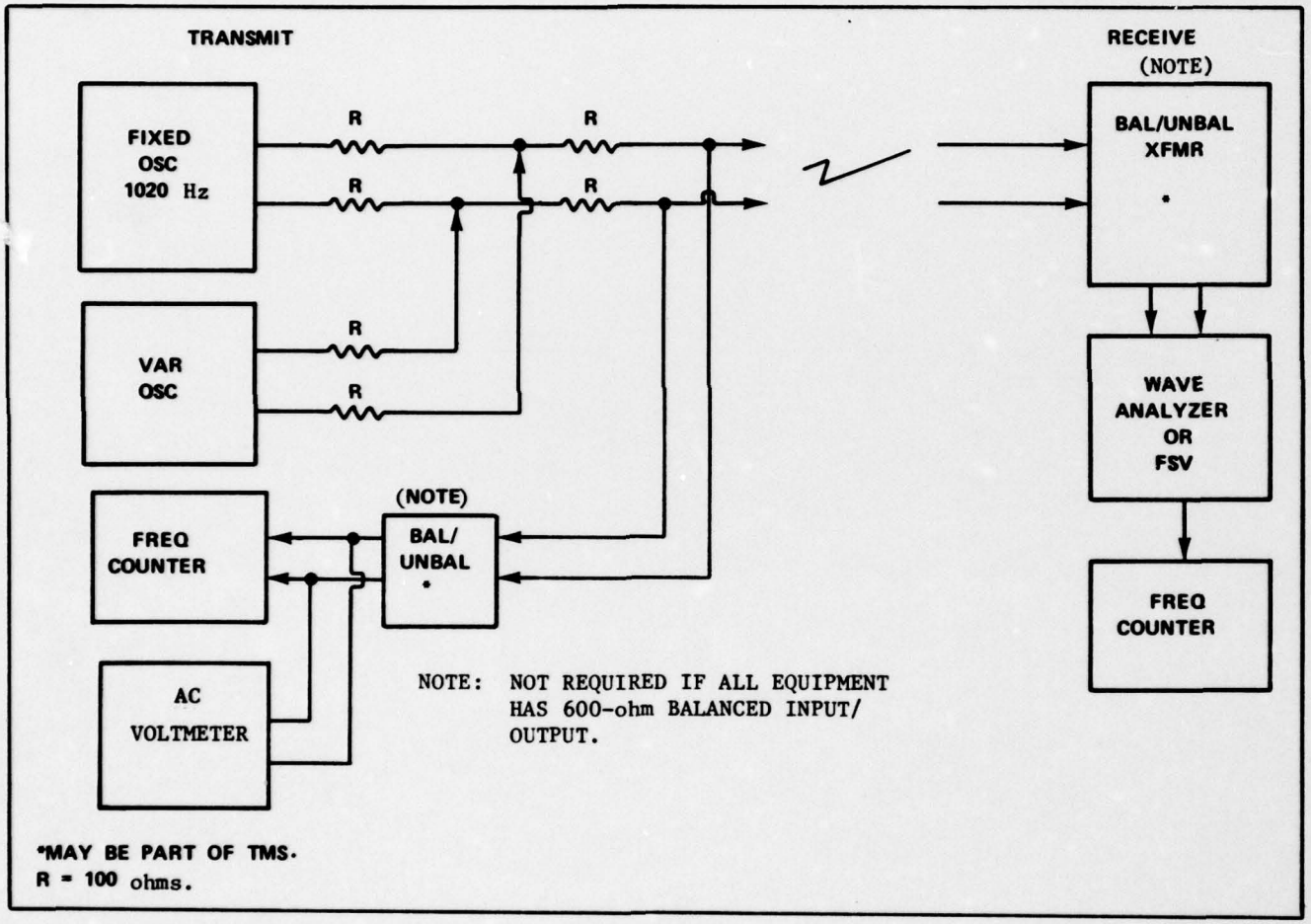


Figure 67-2. Voice channel frequency response test setup.



67-7

CCP 702-11

Figure 67-3. Voice channel frequency response (with holding tone) test setup.

CHAPTER 68

IDLE VOICE CHANNEL CIRCUIT NOISE (DT-265)

68-1. GENERAL.

a. The purpose of this test is to measure the idle voice channel noise either on a multiplex loop or link basis.

b. The idle channel noise should be measured in C-message and 3-kHz flat weighting although C-message weighting more nearly represents the frequency spectrum used for voice communications. The flat weighting measurements will provide an indication of ineffective grounding, shielding, and ground loops within the facility or equipment under test.

c. This test may be performed at any of the test points shown in figure 68-1. If verifying the multiplex performance to the specifications contained in paragraph 68-2, the measurements must be performed at the multiplex channel output.

d. If this test is performed on a link basis, it has some limitations which may influence the test results. The major limitation is that the measurements are made with a noise measuring set and the level fluctuates with time. As a result, inaccuracies are introduced by trying to visually estimate the average value of the oscillating meter pointer. To overcome these inaccuracies, it may be necessary to perform chart recordings of the idle channel noise as described in DT-268.

e. Due to the low level of signals involved, the accurate measurement of noise entails care and attention to detail by test personnel. Particular care should be given to providing good ground, effective shielding, and correct terminations, and to avoiding ground loops.

f. This test may be performed on contractor EF&I systems to ensure that they conform to the contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test activities as directed. On completion of an installation, all channels should be tested to ensure that they meet the specifications. This also serves as a shakedown of the installation. Follow-on quality assurance inspections may examine all channels or use a sampling technique that provides a satisfactory confidence level of system performance.

68-2. SPECIFICATIONS.

a. As a design objective, the noise measured at the receiving end of any idle audio channel of a long haul TDM/PCM reference voice bandwidth link, when referenced to the zero transmission level point, shall not exceed 400 pWp0 (at 26 dBrnc0). (MIL-STD-188-100)

b. The idle channel noise on the TD-1192 (AN/FCC-98) shall not exceed 23 dBrnc0 measured at any channel output with all other channels terminated in their specified impedance. (CCC-74047)

c. The end-to-end channel noise on the CY-104 and the AN/FRC-162 and VICOM 4000-2 system, with all other channel units terminated, shall produce a reading greater than +22 dBm0p. The back-to-back noise performance of the CV-3034, when used, shall exceed 50 dB when measured with F1A weighting relative to a 1000-Hz test tone at the -6 dBm input level for -30 to 0 dBm input level.

d. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

68-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Noise measuring set.

c. Voltmeter.

d. Balanced/unbalanced transformer.

e. Oscilloscope.

68-4. TEST PROCEDURES.

a. For each voice frequency channel to be tested, transmit a 0-dBm0, 1020-Hz test tone to the receiving end before performing the noise measurement. A standard -10 dBm0 test tone may be required on operational systems to preclude the possibility of interfering with traffic signals.

b. At the receive end, measure the level of the 1020-Hz tone to verify that the channel output levels are within ±0.25 dB. Channels that are out of tolerance should be corrected before performing the test.

c. Connect the test equipment as shown in figure 68-1 and allow approximately 30 minutes for warmup and stabilization.

d. At the transmit end, terminate the audio oscillator into a 600-ohm precision resistor and ajust the output for 0 or -10 dBm0 at a frequency of 1020 Hz. Omit the balanced/unbalanced transformer as shown in figure 68-1 if the oscillator has a 600-ohm balanced output. Verify the accuracy of the idle channel noise measuring instrument by inserting a known tone level from the oscillator into the noise measuring set and verifying the level accuracy. This should be accomplished at the low (-50 dBm), mid (-30 dBm), and high (-10 dBm) levels.

e. Connect the test equipment as shown in figure 68-2, depending on the test requirements. The 1st level multiplex shown in the figure may be an AN/FCC-98, AN/FCC-97, VICOM 4000-2, AN/GSC-24, etc. The 2d level multiplex may be a TD-1193, VICOM 4000-2, AN/GSC-24, etc. If testing the multiplex/demultiplex noise performance, the 1st or 2d level multiplex output may be looped at the bipolar output to the bipolar input or at the NRZ output/input depending on equipment configuration. If performing the test over the link on an end-to-end basis, the test tone should be inserted at the transmit circuit patch bay and the noise measured at the receive circuit patch bay.

f. At the transmit end:

(1) Terminate all channels except the channel under test into 600 ohms or as specified in the equipment technical manuals. If a 50-kb/s module is installed in the TD-1192 (AN/FCC-98), the impedance may be 78 ohms balanced or 50 ohms unbalanced depending on the strapping within the module. The AN/GSC-24 input impedance may be 600 ohms minimum or 75 ohms for data input and 600 ohms balanced for voice input.

(2) Measure the peak-to-peak voltage level of the PCM signal at (D) and (E) of figure 68-2, depending on equipment configuration. Record the measurements on figure 68-3 (USACC Form 659-R)

g. On the CY-104 throw all switches down at the transmit and receive terminal common equipment and verify that all alarms are extinguished. Place all channel make-busy switches in the up position.

h. If performing the test in a multiplex loop, connect a patch from the multiplex bipolar or NRZ output to the demultiplexer input.

i. At the receive end:

(1) Connect the noise measuring set to the receive channel under test as shown in figure 68-2. With the oscilloscope, measure and record the peak-to-peak voltages at points (F) and (G) of figure 68-2.

(2) Set the idle channel noise meter as follows:

(a) To 600 ohms termination or as required for the equipment under test.

(b) Function to voice frequency balanced.

(c) Response to normal. If problems are encountered with wide variations of the meter pointer, use the damped position.

(d) Flat weighting to 15 kHz.

(3) With the noise measuring set, measure the noise in each channel using the 3-kHz flat weighting and enter the dBm and dBrnO levels on the data sheet.

(4) Change the weighting network of the instrument to C-message and repeat the measurement for each channel. Record the results on the data sheet.

(5) If the RSL is being recorded during this test, determine the median RSL over the entire period and enter the results on the data sheet. If the RSL is fairly stable and recording is not being made, obtain the RSL value from the RSL versus AGC curve plotted during DT-224.

j. Reverse the direction of transmission and repeat subparagraphs a through i above for each channel.

k. If the system is in traffic, it may not be possible to terminate all channels unless an authorized outage has been obtained. In this case, terminate all spare channels except the channel under test and patch the traffic to a spare channel on a circuit-by-circuit basis.

l. A test setup for automated test procedures and recording of test results is shown in figure 66-5. This test is fully described in a separate document still to be published.

68-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for compliance with specified requirements. If a significant level difference exists between C-message and flat weighting measurements, the responsibile activity should be advised of possible grounding and shielding problems.

b. Summarize the test results on figure 3-7 (DD Form 2091).

c. Remove all test equipment and restore the system to its normal configuration.

d. If the system fails to meet specifications, notify the responsible activity of required corrective actions.

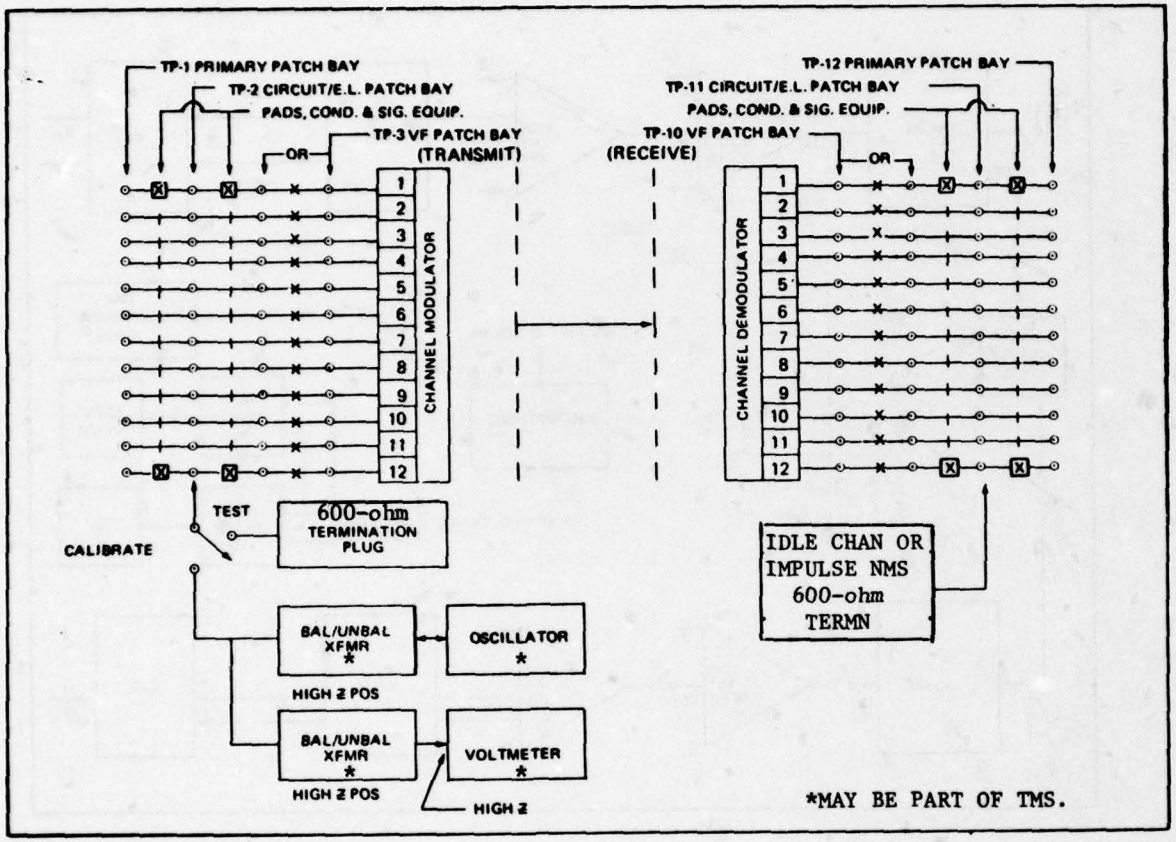


Figure 68-1. Test point designations.

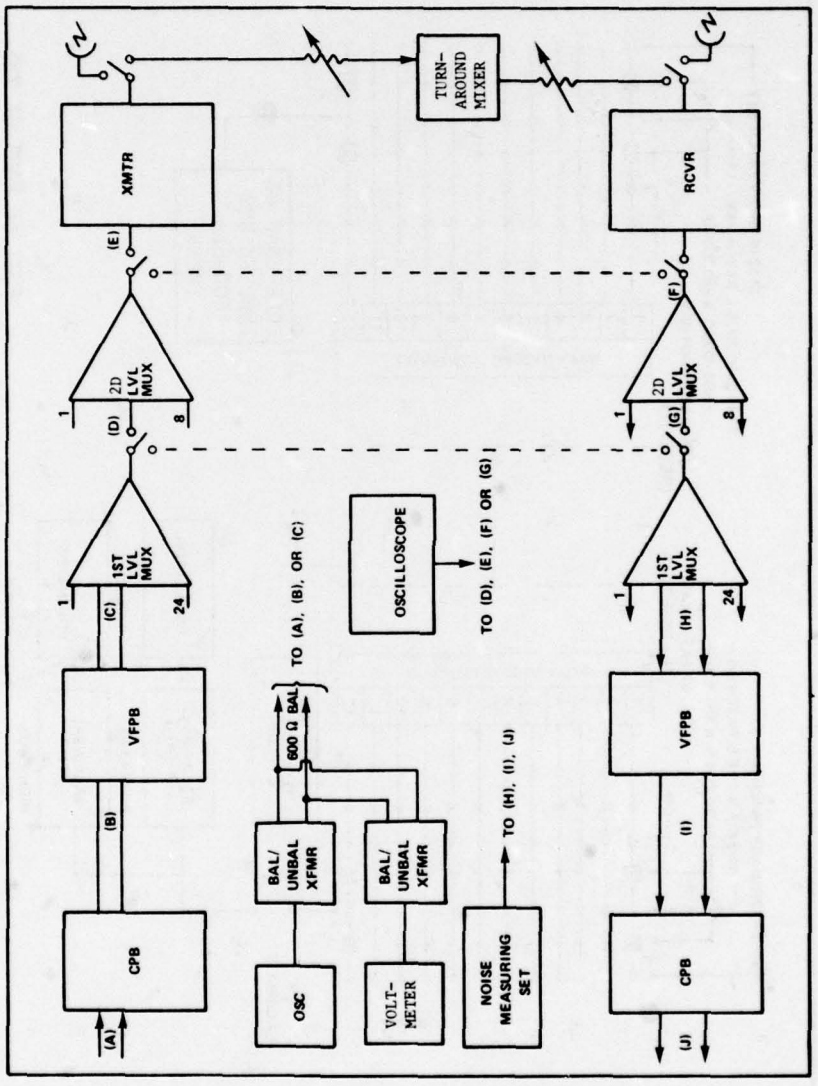


Figure 68-2. Idle voice channel circuit noise (manual) test setup.

CHANNEL NOISE PERFORMANCE
(CCR 702-1-3)

DATA SHEET

PAGE OF PAGES

DATE (Day, Mo, Year)

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

TP dBm	TP dBm0	1ST LVL MUX TYPE _____ VPP	2D LVL MUX TYPE _____ VPP	LINK LOOP: ☐ RF ☐ 1ST LVL MUX ☐ 2D LVL MUX

CHAN NO.	INPUT TONE FREQ Hz	INPUT TONE LVL dBm	RCVD TONE LVL dBm	MEASURED NOISE PERFORMANCE 3-kHz FLAT dBm	3-kHz FLAT dBrn0	C - MSG dBm	C - MSG dBrnc0	S/N S/Nq	MDN RSL

MEDIAN S/N AND S/Nq AT 1020 Hz _____ dBm _____ dBrnc0

USACC FORM 659-R
1 MAY 79

Figure 68-3. Channel noise performance data sheet.

CHAPTER 69

IDLE CHANNEL IMPULSE NOISE (DT-266)

69-1. GENERAL.

a. The purpose of this test is to measure the impulse noise level and number of hits on voice frequency channels.

b. The impulse noise measurement will be in terms of the number of hits per unit time above a particular preset noise power level. Normally, the channel impulse noise is measured between the transmit circuit patch bay test point (TP-2) and the receive circuit patch bay test point (TP-11) (chap 1). If there are indications of noise being generated in other parts of the system, additional measurements may have to be made at other test points in order to isolate the source of the noise. If testing the equipment to a design specification, the test would normally be performed with a multiplex loop and the measurement made directly at the channel output.

c. Impulse noise counters are designed to measure impulse noise and consist of a weighting network, a threshold detector, and a counter of events above a preestablished threshold. The measuring sets may also include a timer which can be set to automatically count the events above a certain threshold for a specific time interval. The time limit and threshold can be set independently at prescribed levels so that the number of noise spikes or bursts can be correlated to a specific level over a specified time interval. The majority of impulse noise measuring sets incorporate at least three separate counting devices that can be adjusted to different threshold levels.

d. Due to the nature of impulse noise, care must be exercised by test personnel to ensure that the instrumentation is not being influenced by ground loops, ineffective grounding and shielding, or the test setup.

e. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

69-2. SPECIFICATIONS.

a. No more than two impulses during any 30-minute interval shall exceed 55 dBrnc0, at any audio output interface of the TD-1192 (AN/FCC-98). (CCC-74047)

b. For the AN/FRC-162 and VICOM 4000-2 system, DCA circuit parameters shall apply (app C).

c. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

d. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

69-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Voltmeter.

c. Balanced/unbalanced transformer (as required).

d. Noise measuring set. (May be part of TIMS.)

e. Precision terminating resistors (as required).

f. Oscilloscope.

69-4. TEST PROCEDURES.

a. Initially connect the test equipment as shown in figure 68-1 and allow approximately 30 minutes for warmup and stabilization.

b. At the transmit end, terminate the transmission measuring set (oscillator) into 600 ohms and adjust the output to 0 dBm at 1020 Hz. The output should be set to -10 dBm0 for those systems that are carrying operational traffic.

c. Connect the test equipment as shown in figure 69-1, depending on whether a link or loop test is being performed.

d. For each channel to be tested, transmit a 0 dBm0 or -10 dBm0, 1020-Hz test tone to the receiving demultiplex point. At the channel receiving end, record the tone level in dBm. Compute and record the error in dB. This will verify the channel level adjustments as well as ensure the validity of the noise measurements.

e. Adjust the impulse noise counter in accordance with the operating instructions and connect the instrument to the receive channel at the circuit patch bay (TP-11) unless instructed otherwise. Set the instrument for 600 ohms termination and 3-kHz flat weighting. If testing the equipment to the specifications of paragraph 69-2, place the instrument in C-message weighting. Indicate the type weighting used on figure 69-2 (USACC Form 660-R).

f. Initially set the noise counters as close as possible to 35, 45, and 55 dBrnc0 if testing the TD-1192 (AN/FCC-98), and 52, 62, and 72 dBrnc0 if testing circuit requirements in accordance with paragraph 106-2c. Adjust the counters to correspond to the equipment reference level at which the measurement are to be made.

g. If the highest level counter runs continuously, adjust all counters levels in steps until the highest level counter runs only occasionally (not more than two counts in 30 minutes for the TD-1192 (AN/FCC-98) and one count per minute or less for circuit testing). Maintain a 10-dB separation between the counter levels unless directed otherwise.

h. Record the impulse noise for a minimum of 15 minutes if circuit testing in accordance with DCAC 300-175-9, and for 30 minutes if testing the TD-1192 (AN/FCC-98) to specifications. Record the low, mid, and high impulse noise counts on the data sheet.

NOTE: At times it may be necessary to obtain a long-term measurement of impulse noise during acceptance testing of a system. If required, long-term measurements can be performed using the same basic procedures.

i. After completing the short-term measurements as described above, establish a long-term measurement on one of the channels previously tested. If required, the long-term measurement may be taken on more than one channel; therefore, the channels selected for testing should represent the worst, best, and average as determined during the short-term testing. The long-term impulse counts should be taken for 8 hours or more. If the system is in traffic, it should be conducted during heavy or at least normal traffic loading.

j. Once each hour, record the total counts on the data sheet and the RSL, as taken from the previously calibrated AGC versus RSL curve. If a stripchart recorder is available, the RSL should be recorded and the impulse noise counts correlated to the RSL data. Do not set the counters to zero each hour but ensure that no counter passes its maximum count and recycles without being detected.

k. Repeat the short-term measurement for at least three channels within a system and if testing the TD-1192 (AN/FCC-98) to specifications, repeat the test for each channel and equipment.

l. Reverse the direction of measurement and repeat the test for the opposite direction of transmission.

69-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the data for compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system or equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

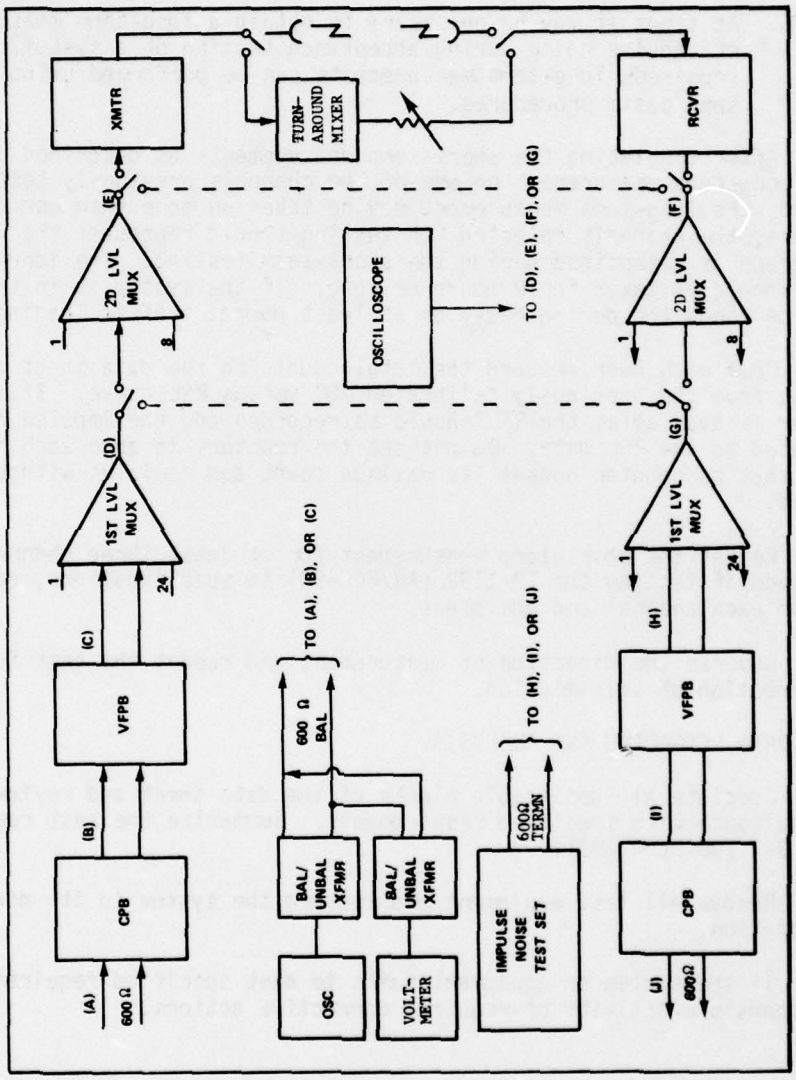


Figure 69-1. Idle channel impulse noise test setup.

IDLE CHANNEL IMPULSE NOISE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGR SIGNATURE
REF TEST TONE LEVEL		XMT VF TP USED	RCV VF TP USED
dBm0	dBm	dBm	dBm
RCV MEAS LEVELS		XMT MEAS LEVELS	CONFIGURATION
1ST LVL MUX _____ VPP 2D LVL MUX _____ VPP		1ST LVL MUX _____ VPP 2D LVL MUX _____ VPP	☐ RF LOOP ☐ 1ST LVL MUX LOOP ☐ 2D LVL MUX LOOP

CHANNEL NO.	RECEIVED TEST TONE LEVEL		NOISE WEIGHTING ☐ FLAT ☐ C-MSG NOISE METER SETTING (dBrn0)			TEST PERIOD DURATION (min)	MEDIAN RSL (dBm)
	MEAS (dBm)	ERROR (dB)	LOW	MID	HIGH	IMPULSE NOISE COUNTS	

COMMENTS

USACC FORM 660-R
1 MAY 79

Figure 69-2. Idle channel impulse noise data sheet.

CHAPTER 70

VOICE CHANNEL CROSSTALK (DT-267)

70-1. GENERAL.

a. The purpose of this test is to measure the total amount of crosstalk within a voice channel/circuit from all causes.

b. Crosstalk may be caused by an impedance irregularity in the circuit, or capacitive and inductive coupling between the disturbing and disturbed channels/circuits. These conditions can occur at any point in a communications system, particularly in the distribution frame wiring and cabling, and in the multiplex. Crosstalk can also occur at any point within the transmission system if the traffic or test signals are applied at a higher level than the design characteristics of the system.

c. Due to the low level of signals involved in the measurement of crosstalk, particular care should be given to providing good grounds, effective shielding, and correct terminations.

d. Crosstalk attenuation is expressed as a ratio of the transmit signal power delivered by the source to a disturbing channel to the power received at the point of measurement on the disturbed channel, both channels being correctly terminated. It is generally more meaningful, when dealing with a complete transmission system, to express crosstalk in terms of a signal/crosstalk ratio which takes into account any difference in the nominal relative levels of the measurement points. This is achieved by expressing both of the measured levels in dBm0.

e. Voice channel crosstalk measurements are normally made between the transmit circuit patch bay (TP-2) and the receive circuit patch bay (TP-11). If there are indications that the measured crosstalk between these test points does not meet applicable standards, additional measurements may be made between other combinations of test points in order to isolate the source of the excessive crosstalk.

f. Because of the time required to measure crosstalk in the large number of possible combinations of disturbing and disturbed channels, these measurements should be made on those channels which are most likely to cause a crosstalk condition. Possible crosstalk channels for a D3-to-D3 and D3-to-D2 channel banks are shown in table 70-1. Refer to the technical manual for the equipment under test if different than that contained in the table.

g. This test may be performed on contractor EF&I systems to ensure that they conform to specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. The number of channels/circuits to be tested will normally be specified; however, an adequate number of measurements should be made to provide a high degree of

confidence that the system performance and installation meets specified performance requirements.

70-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) The crosstalk measured at either the transmit (near) end or the receive (far) end of two multiplex terminals shall not exceed 25 dBrncO when a O-dBmO test tone level at 1020±5 Hz is inserted with all other channels terminated in their specified impedance.

(2) The multiplex/demultiplex terminal shall meet the compatibility requirements when connected end-to-end with a D2 channel bank, a D3 channel bank, or an HY-12 when the HN-74 interface device is interposed between the HY-12 and the multiplex/demultiplex terminal.

b. The crosstalk level on the AN/FRC-162 and VICOM 4000-2 system shall be less than 65 dBm with a O-dBmO, 1020-Hz test tone.

c. The multiplex/demultiples equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

d. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contact specifications.

70-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Balanced/unbalanced transformer (as required).

c. Frequency selective voltmeter.

d. Wave analyzer.

e. Noise measuring set.

f. Voltmeter.

g. Precision terminations (as required).

h. Oscilloscope.

70-4. TEST PROCEDURES. Complete the top portion of figure 70-1 (DD Form 2114). Change the SG column to read 1st level multiplex, and the G column to 2d level multiplex.

a. Transmit End Crosstalk.

(1) Connect the test equipment as shown in figure 70-2 and allow approximately 30 minutes for warmup and stabilization. As shown in the figure, crosstalk measurements may be performed at any point within a station but are generally made at the circuit patch bay.

(2) At the transmit end, insert a 1020-Hz, 0-dBm0 tone into the voice channel which is to act as the disturbing channel. Insert the tone at the circuit patch bay or at any other designated test point. Ensure that the oscillator and noise measuring set are set for the appropriate impedance of the test point or equipment under test. This would normally be 600 ohms balanced for voice frequency channel operation.

(3) If testing the equipment in a local loop configuration, patch the multiplex bipolar or NRZ (as applicable) output data signal to the demultiplexer bipolar or NRZ input terminal.

(4) At the receive end, terminate the selected disturbing channel in 600 ohms or its specified impedance. Measure the level of the 1020-Hz tone with the noise measuring set. Ensure that the level is within the specified tolerance (±1 dB). Measure and record the composite data level in VPP at the input to the 1st and 2d level multiplexers.

(5) At the receive end, perform an accuracy check on the noise measuring set using the transmission measuring set with a calibrated output level meter. Connect the noise measuring set to the oscillator. For a given weighting, compare the readings from the noise measuring set with the calibrated output level meter. As an example, set the oscillator to 1020 Hz and the output level to -60 dBm. The level measuring set should read 30 dBrnc0 if using C-message weighting.

(6) At the receive end, terminate the transmit input of the channel to be tested (disturbed channel) into a 600-ohm terminating resistor.

(7) At the transmit end, terminate the receive end of the channel to be tested (disturbed channel) into the noise measuring set at the circuit patch bay. Adjust the noise measuring set to 3-kHz flat weighting and measure the noise in the channel. Switch to C-message weighting to ensure that 60-Hz components are not masking the noise measurement or influencing the crosstalk readings. If a difference of more than 3 dB exists between the C-message and flat weighting measurements, then the test should be completed using C-message weighting. Additional tests should be performed within the station to determine the cause of the disparity between the two readings.

(8) At the transmit end, alternately connect and disconnect the tone on the disturbing channel. Record the noise levels with the tone on/tone off in

the near crosstalk column of the data sheet. Calculate the difference between the tone on/tone off levels and record the results in the noise level difference column of the data sheet.

(9) If the measured difference is 2 dB or greater, connect the frequency selective voltmeter (narrow mode) or the wave analyzer in place of the noise measuring set. Measure the frequencies and the levels of the crosstalk signals in dBm. Record the frequencies and levels on the data sheeet.

NOTE: If the test equipment does not have a balanced input/output, a balanced-to-unbalanced transformer will be required.

(10) Maintaining the same disturbing channel, repeat subparagraphs (2) and (4) through (9), above, for other channels that will most likely experience crosstalk as shown in table 70-1.

(11) Repeat the procedure described in subparagraphs (1) through (10), above, for other disturbing channels as required.

b. Receive End Crosstalk.

(1) Connect the test equipment as shown in figure 70-3. At the transmit end, insert a 1020-Hz, 0-dBm0 tone into the voice channel which is to act as the disturbing channel (preferably the same channel used in the transmit end crosstalk test). The tone should be inserted at the circuit patch bay unless otherwise directed or when testing equipment is in a back-to-back configuration.

(2) At the receive end, terminate the selected disturbing channel into the noise measuring set or voltmeter. The measured level of the 1020-Hz tone should be within ±1 dB of the 0-dBm0 transmitted tone. Calculate and record the tone level error on the data sheet.

(3) At the transmit end, terminate the input of the channel to be tested (disturbed) with a 600-ohm terminating resistor. The channel sould be terminated at the circuit patch bay unless otherwise directed.

(4) At the receive end, terminate the receive end of the channel to be tested (disturbed) into the noise measuring set at the circuit patch bay or at the equipment as appropriate. Adjust the noise measuring set to 3-kHz flat weighting and measure the noise in the channel with the oscillator disconnected at the transmit end. Switch to C-message weighting to ensure that the 60-Hz components are not masking idle circuit noise. If more than 3-dB difference exists between the two readings, proceed with the test using C-message weighting. Additional tests at other test points within the station should be performed to isolate the reason for the difference in readings.

(5) At the transmit end, alternately connect and disconnect the tone on the disturbing channel.

(6) At the receive end, measure and record the noise levels with the tone on and tone off. Calculate the difference between the tone on/tone off noise levels and record the results on the data sheet.

(7) If the difference is 2 dB or greater, connect the frequency selective voltmeter or wave analyzer (narrow mode) in place of the noise measuring set and measure the frequencies and levels of the crosstalk in dBm.

(8) Maintaining the same disturbing channel, repeat subparagraphs (1) through (7), above, for the remaining channels to be tested.

(9) Repeat subparagraphs (1) through (8), above, for other disturbing channels to be tested.

c. Combine Transmit End and Receive End Crosstalk. Using the procedures described in paragraphs 70-4 a and b, above, perform a combined crosstalk test as shown in figure 70-4. Do not energize the disturbing channel in both directions at the same time when performing the test in both directions of transmission.

d. Adjacent Channel Crosstalk (AN/FCC-97). The following procedures supplement those outlined above. However, the sequence will be in accordance with Western Electric sampling techniques: Channel 12, 13, 1, 17, 5, 21, 9, 15, 3, 19, 7, 23, 11, 14, 2, 18, 6, 22, 10, 16, 4, 20, 8, and 24.

(1) Disconnect all test equipment including plugs, patch cords, and leads from the transmit and receive terminals.

(2) At the receive terminal, connect the noise measuring set to the voltmeter jack of the 7060 test panel. Set the noise measuring set to 600 ohms termination, C-message weighting (fig. 70-5). The noise measuring set should be set for internal battery operation to preclude ground currents from entering the meter through the local power source.

(3) Connect the oscillator (1020 Hz, 0 dBm0) to the oscillator in-jack of the 7060 test panel. Set the selector switch to set oscillator and adjust the input test tone for 0 dBm0 on the level meter. Verify the accuracy of the internal meter by bridging an external voltmeter across the output of the oscillator. Set the 7060 selector switch to crosstalk.

(4) Remove the terminating plug from the channel 12 transmit lineup jack and patch the transmit lineup jack of the 7060 test panel to the channel 12 transmit lineup jack.

(5) Patch the receve lineup jack of channel 13 to the receive lineup jack of the 7060 test panel. Set the test panel selector switch to crosstalk. Measure and record the reading on the data sheet.

(6) At the transmit end, remove the test tone from the disturbing channel (12) and open the channel unit transmit jack. Connect the test tone to the remaining channels according to the sequence in paragraph 70-4d, above, Repeat the procedure.

(7) At the receive end, repeat subparagraphs (5) and (6), above, for the remaining channels to be tested.

e. Crosstalk (AN/FCC-98).

(1) Determine if the channel transmit input is strapped for 0 or -16 dBm. For the crosstalk test, all channels should be strapped for 0-dBm operation on the transmit side and either 0 or +7 dBm on the receive side. If strapped for +7 dBm receive output, this level must be considered in arriving at the total level of crosstalk.

(2) Connect the bipolar or NRZ (depending on strapping) multiplex composite output to the demultiplex MBS input as sown in figure 70-6.

(3) Terminate the receive jack of all voice frequency modules on the transmit end with 600 ohms except the channel under test.

(4) At the transmit end, set the BITE voice frequency function switch to channel level transmit. If using the BITE 1020-Hz oscillator, set the oscillator level toggle switch to 0 or -16 dBm depending on the channel strapping. If a separate oscillator is being used, set the frequency to 1020 Hz and the output level for 0 or -16 dBm and connect the oscillator to the channel 1 transmit jack.

(5) At the receive end, connect the noise measuring set to the receive voice frequency channel output as shown in figure 70-6. Set the noise measuring set controls as follows:

(a) Response switch to damp.

(b) Noise weighting to C-message.

(c) Range switch to approximately 20 dBrn depending on channel strapping.

(d) Input level to termination noise.

(e) 600-ohm balance/noise measuring function switch to in.

(6) At the receive end, connect the voice frequency channel receive jack to the noise measuring set. The selected channel can be any voice frequency channel except the channel on which the tone is being transmitted.

(7) Measure and record the crosstalk level on the data sheet. The level should be less than 25 dBrnc0 for 0 dBm output or 32 dBrnc for +7 dBm output, depending on the channel strapping.

(8) Repeat subparagraphs (1) through (7) above, for each channel in the sequence or as idrected.

(9) Reverse the direction of transmission and repeat the procedures.

70-5. DATA RECORDINGS AND ANALYSIS.

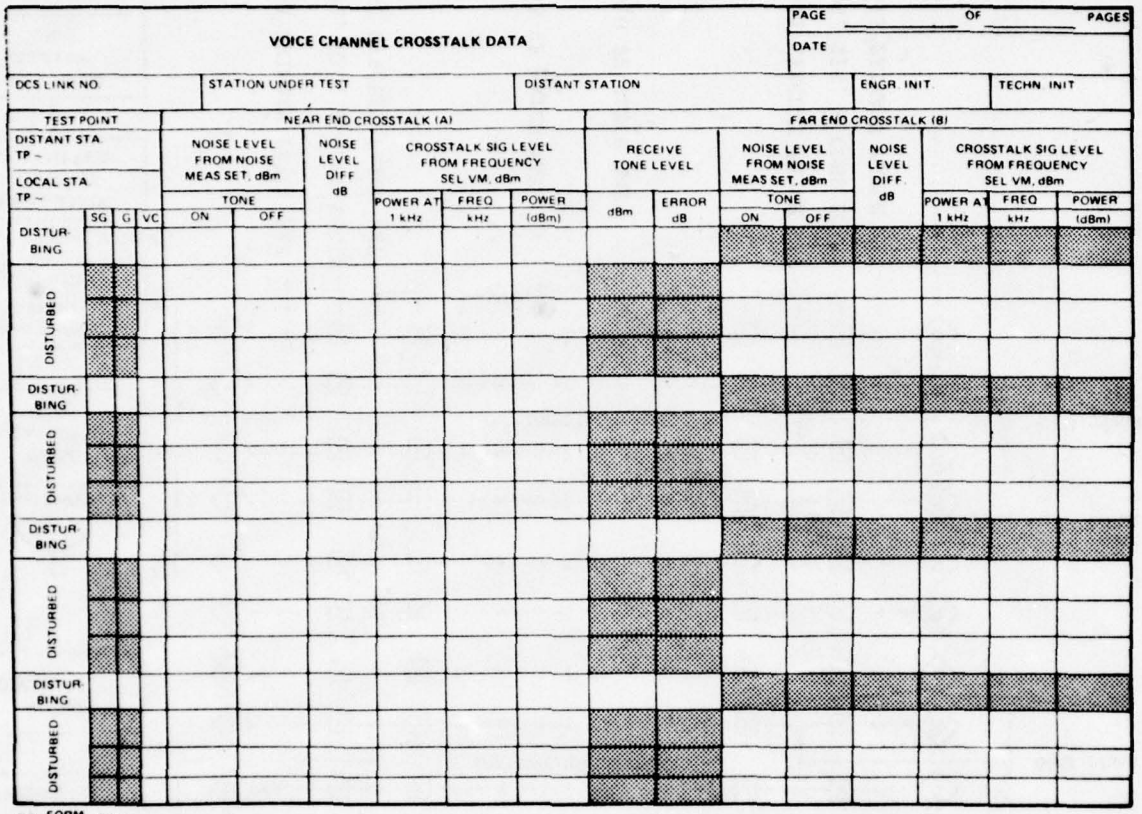
a. Complete all applicable blocks of the data sheet and review the test results to ensure that the system meets specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system fails to meet specifications, notify the responsible activity of required corrective actions.

Table 70-1. Possible Crosstalk Channel Configuration

CHANNEL UNDER TEST	MOST LIKELY INTERFERING CHANNEL(S)	CHANNEL UNDER TEST	MOST LIKELY INTERFERING CHANNEL(S)
D3-to-D3 CHANNEL BANK			
1	24-23	13	12-11
2	1-24	14	13-12
3	2-1	15	14-13
4	3-2	16	15-14
5	4-3	17	16-15
6	5-4	18	17-16
7	6-5	19	18-17
8	7-6	20	19-18
9	8-7	21	20-19
10	9-8	22	21-20
11	10-9	23	22-21
12	11-11	24	23-22
D3-to-D2 CHANNEL BANK			
1	13-12	13	12-24
2	14-11	14	11-23
3	15-9	15	9-21
4	16-10	16	10-22
5	17-1	17	1-13
6	18-2	18	2-14
7	19-3	19	3-15
8	20-4	20	4-16
9	21-5	21	5-17
10	22-6	22	6-18
11	23-7	23	7-19
12	24-8	24	8-20



VOICE CHANNEL CROSSTALK DATA

PAGE ____ OF ____ PAGES

DATE

DCS LINK NO. | STATION UNDER TEST | DISTANT STATION | ENGR. INIT. | TECHN. INIT.

TEST POINT				NEAR END CROSSTALK (A)						FAR END CROSSTALK (B)							
DISTANT STA. TP ~ / LOCAL STA. TP ~				NOISE LEVEL FROM NOISE MEAS SET, dBm		NOISE LEVEL DIFF dB	CROSSTALK SIG LEVEL FROM FREQUENCY SEL VM, dBm			RECEIVE TONE LEVEL		NOISE LEVEL FROM NOISE MEAS SET, dBm		NOISE LEVEL DIFF dB	CROSSTALK SIG LEVEL FROM FREQUENCY SEL VM, dBm		
				TONE			POWER AT 1 kHz	FREQ kHz	POWER (dBm)	dBm	ERROR dB	TONE			POWER AT 1 kHz	FREQ kHz	POWER (dBm)
	SG	G	VC	ON	OFF							ON	OFF				
DISTURBING																	
DISTURBED																	
DISTURBING																	
DISTURBED																	
DISTURBING																	
DISTURBED																	
DISTURBING																	
DISTURBED																	

DD FORM 1 SEP 77 2114

Figure 70-1. Voice channel crosstalk data sheet.

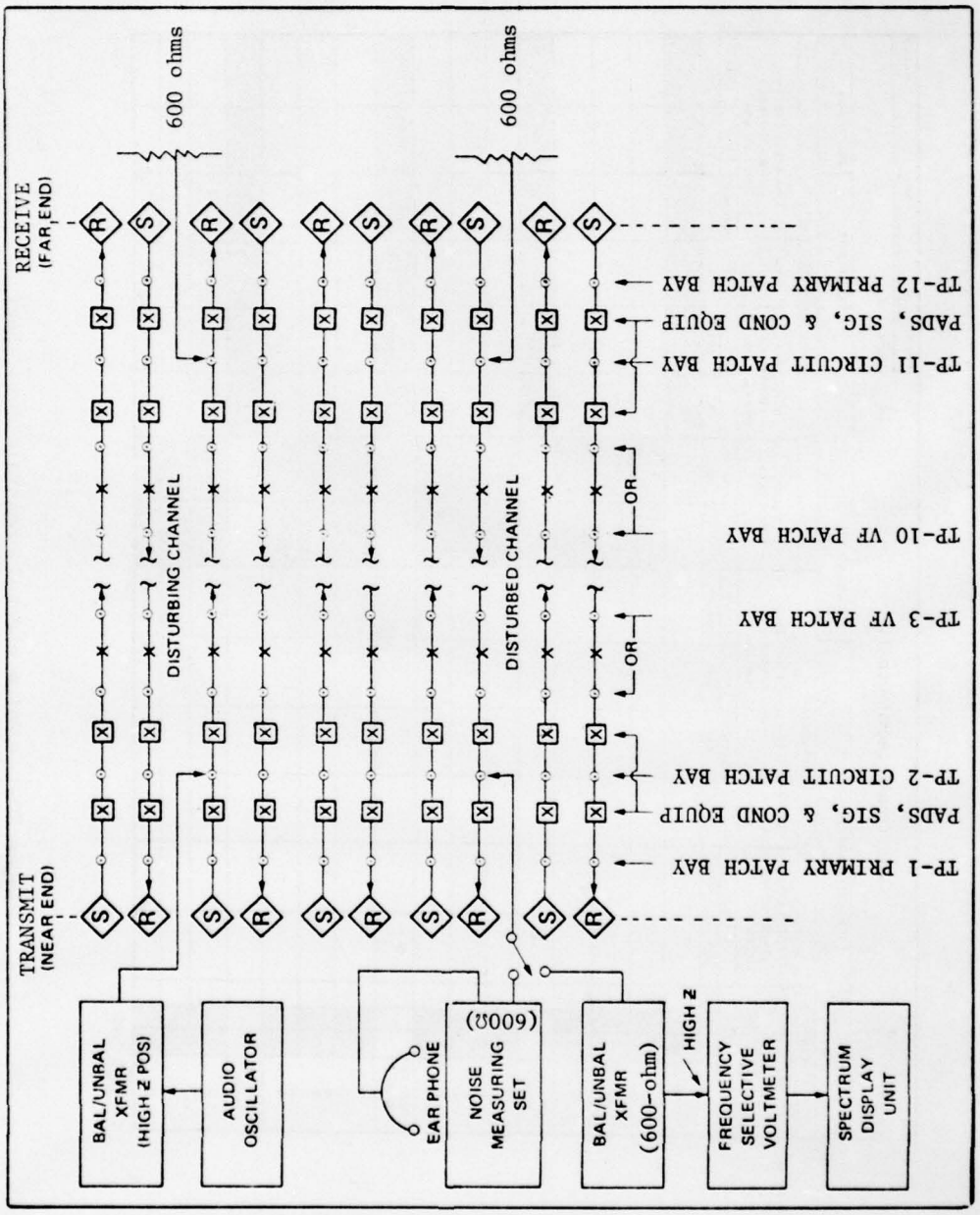


Figure 70-2. Voice channel crosstalk (transmit) test setup.

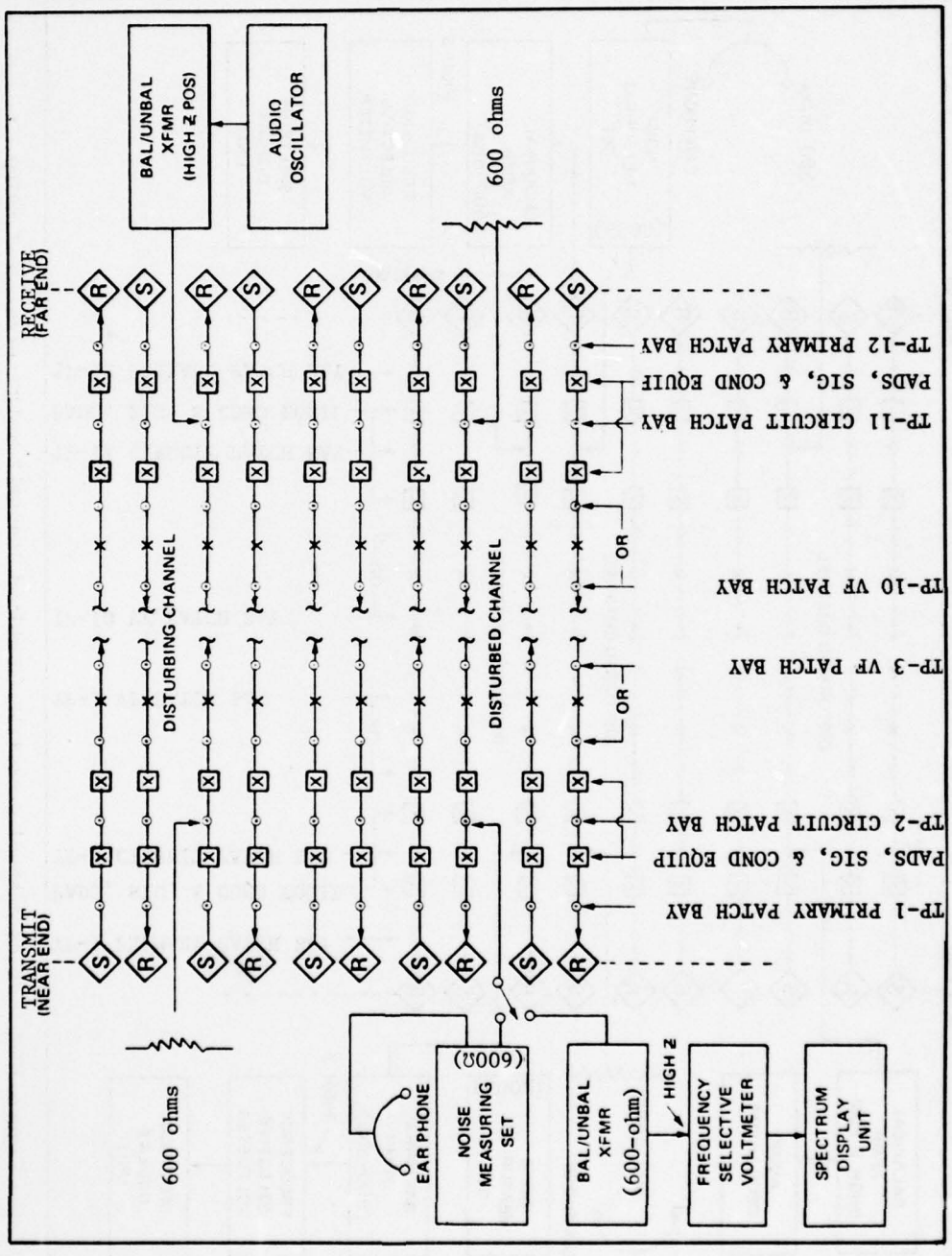


Figure 70-3. Voice channel crosstalk (receive) test setup.

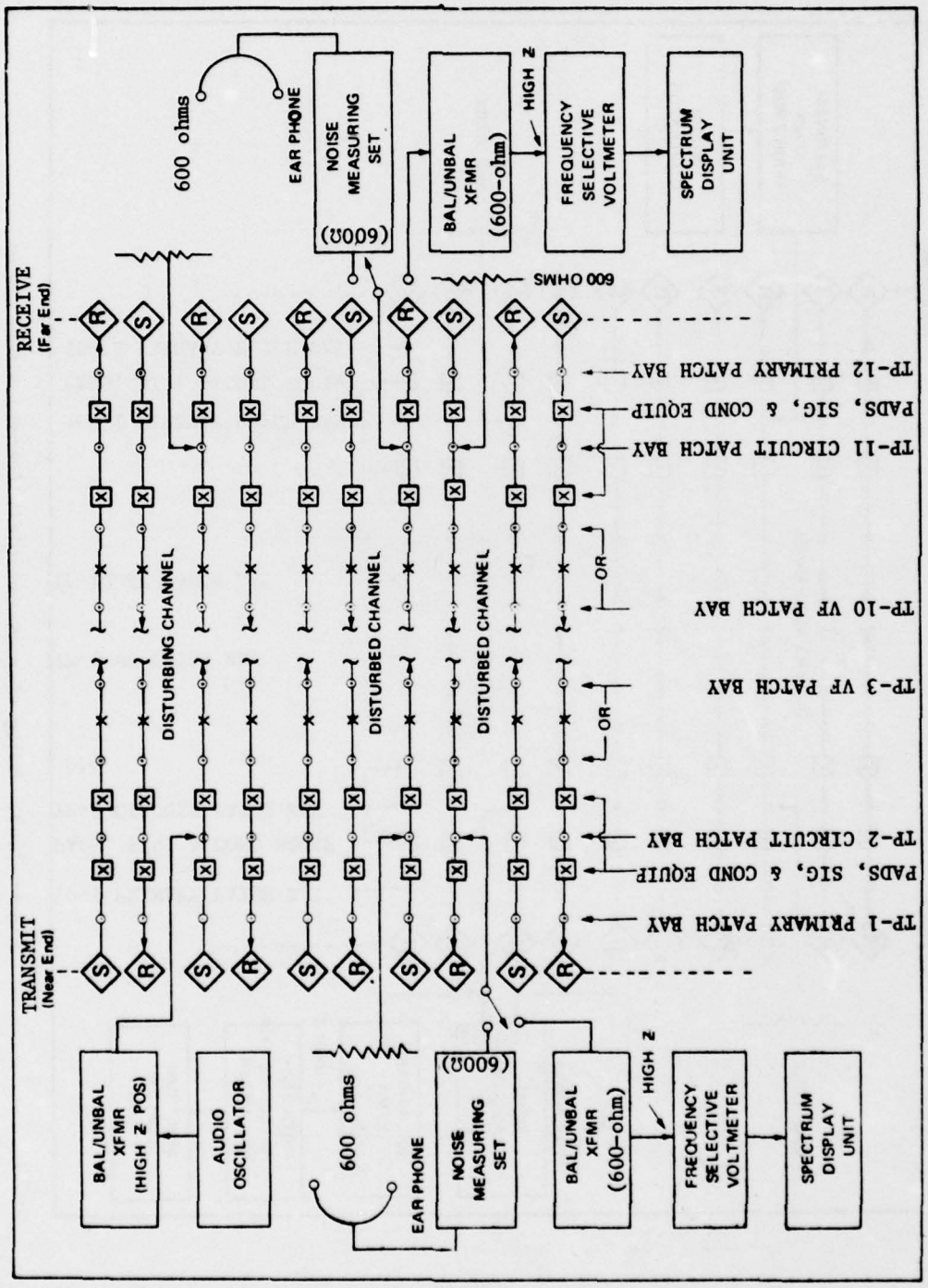
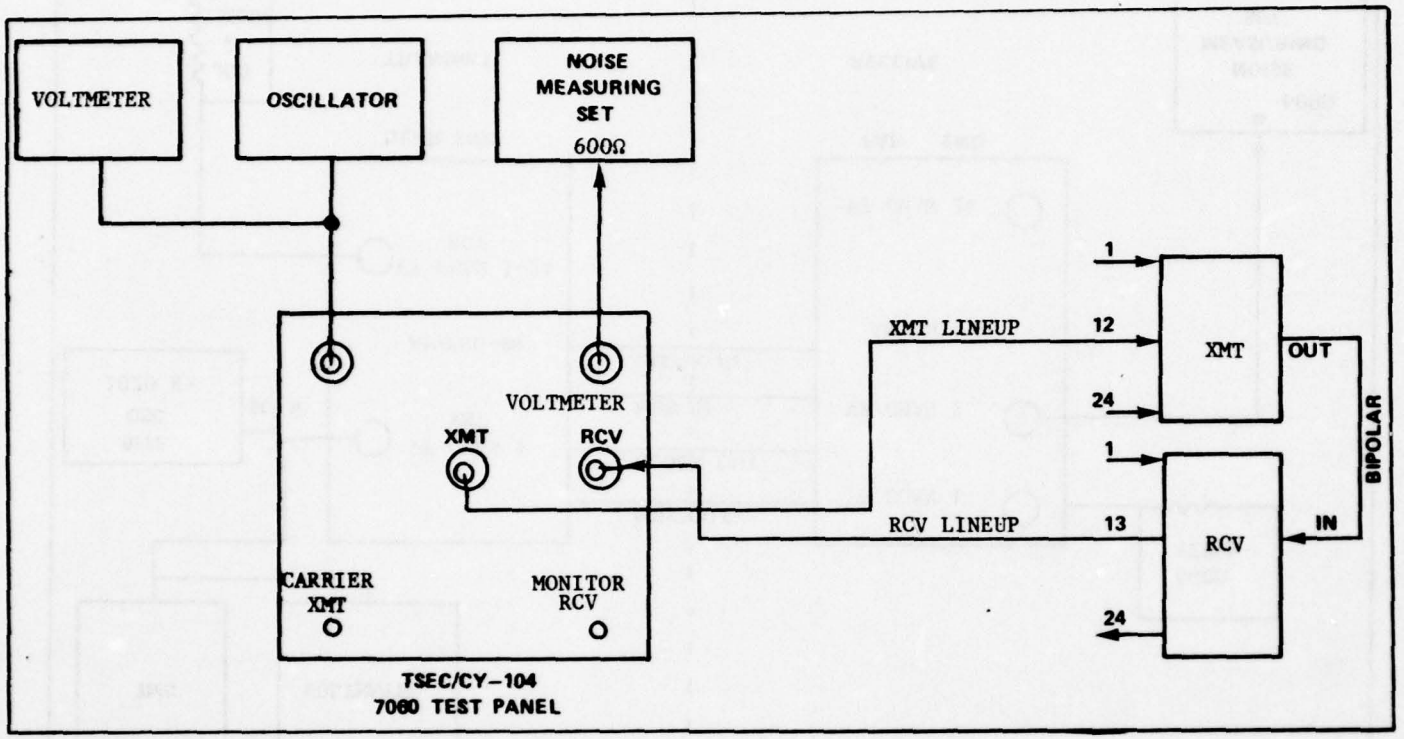


Figure 70-4. Voice channel crosstalk (combined transmit and receive) test setup.



CCP 702-11

Figure 70-5. Adjacent channel crosstalk (TSEC/CY-104) test setup.

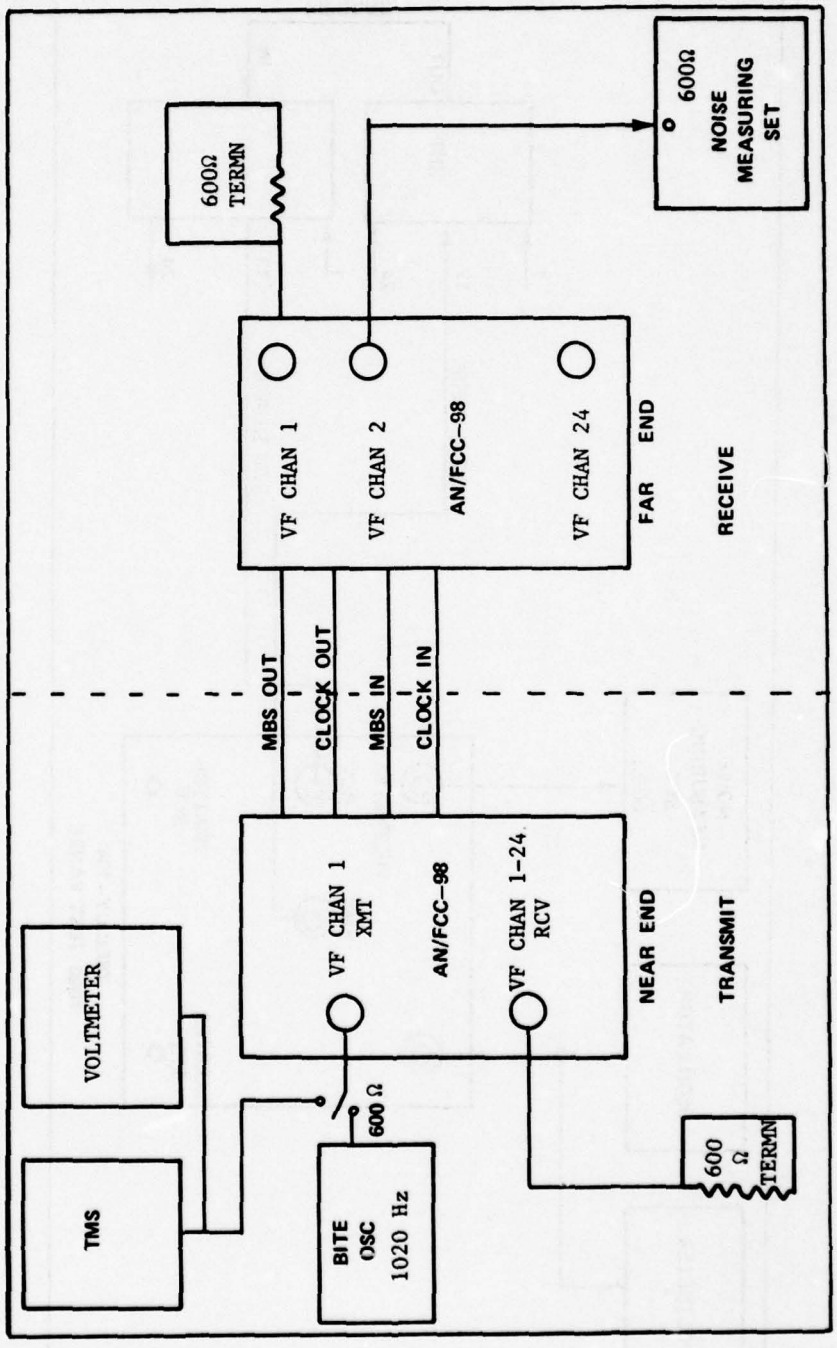


Figure 70-6. Voice channel crosstalk (AN/FCC-98) test setup.

CHAPTER 71

VOICE CHANNEL ENVELOPE DELAY DISTORTION (AUTOMATIC METHOD) (DT-268)

71-1. GENERAL.

a. The purpose of this test is to measure and evaluate the envelope delay distortion characteristics of individual voice frequency channels or other transmission media by using a delay measuring set with automatic sweep across the 4-kHz channel.

b. With the delay measuring set, four automatic sweep methods are possible: end-to-end without reference, end-to-end with return reference, end-to-end with forward reference, and instation equipment measurements. Each method of measurement has its own advantages under various operating conditions and equipment configuration.

c. End-to-end measurements require the line or circuit under test to be measured in one direction only. However, the need to establish synchronization between the modulating signal oscillators at both ends, plus time-consuming adjustments requiring voice coordination, make it a less desirable option when other methods exist.

d. End-to-end with return reference eliminates the necessity of synchronizing the modulating signal oscillators. Modulation is detected from the receiver AM swept carrier at the receive end and applied to an unswept fixed frequency carrier for return to the transmit end where its phase is measured relative to the phase of the modulating signal. This method measures envelope delay in the transmit direction and is particularly useful where measurements are made and recorded primarily at the transmit end. A separate reference return circuit is required for this configuration.

e. End-to-end with forward reference eliminates the necessity of synchronizing the modulating signal oscillators; however, this option may not be available on all delay measuring sets. In forward reference, a modulating signal from the receive end modulating signal generator is transmitted over a fixed frequency carrier to the transmit end where it modulates the transmitter. The receive end operates in the same manner as for return reference, except that the measurements are made and recorded at the receive end instead of the transmit end. A separate forward reference circuit is required for this option.

f. Envelope delay distortion measurements using one delay measuring set can be made on instation equipment such as line conditioning, internal test points of the multiplex, and on circuits transversing one or more types of transmission media.

g. The distortion of a complex waveform, made up of two or more different frequencies, caused by the difference in arrival time of each frequency at the output, is called delay distortion. It is a direct result of nonlinear phase-shift characteristics in the transmission line. The types of delay commonly referred to are:

(1) *Absolute.* Absolute envelope delay is the amount of delay encountered by the modulating energy in a signal between the input and output of any circuit. It is measured by transmitting a narrowband signal at the frequency(ies) of interest using the same reference at the receiver.

(2) *Relative.* Relative envelope delay is the difference in envelope delay at various frequencies but with a specific frequency selected as a reference point for all other frequencies. The delay at the reference frequency is considered to be 0 µsec, and all other frequencies will either have more (positive) or less (negative) delay than the reference frequency.

h. The following procedures (para 71-4) will be repeated for other channels and circuits to be tested. The direction of transmission will be reversed and the test repeated for all channels in the opposite direction.

i. The procedures will apply to the TD-1192 (AN/FCC-98), and the AN/FRC-162 and VICOM 4000-2 system. If the equipment is to be tested in a back-to-back loop, the bipolar or NRZ multiplex output must be looped to the demultiplex input. The delay measuring set (transmit) would be inserted into the channel transmit jack and the receive end into the channel receive jack of the individual channel modules.

j. This test may be performed on contractor EF&I systems or equipment to ensure that they conform the contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test activities as directed. The number of channels or circuits to be tested will normally be specified. However, an adequate number of measurements should be made across the frequency spectrum to provide a high degree of confidence that the system's performance and installation meet specifications.

71-2. SPECIFICATIONS.

a. As a design objective, the envelope delay distortion of a long haul TDM/PCM reference voice bandwidth link over the frequency bandwidth from 600 to 3200 Hz shall not exceed 300 µsec. Between 1000 and 2500 Hz, the envelope delay distortion shall not exceed 125 µsec. (MIL-STD-188-100)

NOTE: It is assumed that the envelope delay distortion of PCM/TDM reference links in tandem is the sum of the envelope delay distortion contributed by the single links.

b. The envelope delay distortion of a TD-1192 (AN/FCC-98) shall not exceed 400 µsec in the frequency band between 500 and 3000 Hz and shall not exceed 175 µsec in the frequency band between 1000 and 2500 Hz. (CCC 74047)

c. The following criteria applies to the AN/FRC-162 and VICOM 4000-2 system.

(1) The design objective for the envelope delay distortion shall not exceed 300 µsec in the frequency band of 600 to 3200 Hz and shall not exceed 125 µsec in the frequency band of 1000 to 2500 Hz.

(2) Typically, the VICOM terminal equipment shall be capable of meeting the D2 requirements which are:

FREQUENCY (0 dBm0 tone) (Hz)	DELAY (µsec)
1150 to 2300	120
1000 to 2500	170
800 to 2700	235

d. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

71-3. TEST EQUIPMENT REQUIRED.

a. Delay measuring set.

b. X-Y recorder.

c. Balanced/unbalanced transformer (as required).

71-4. TEST PROCEDURES.

a. General Delay Measurement Techniques.

(1) Complete the top portion of figure 3-4 (DD Form 2094). Change the channel information block as required to include the 1st and 2d level multiplexers. If additional space is required, use figure 3-7 (DD Form 2091).

(2) Set up the delay measuring set and allow approximately 30 minutes for warmup and stabilization. Adjust the input and output impedance switches for 600 ohms balanced operation. If testing at other than a 600-ohm point, adjust the output impedance and level accordingly.

(3) For balanced operation, remove all shorting straps which may be placed between one side of the input line and ground. Set the delay measuring set for 83-1/3-Hz modulation.

(4) Connect the test equipment as shown in figure 71-1 for end-to-end measurement. Calibrate the delay measuring set and X-Y recorder at the receive end by looping back the output of the delay measuring set to the input, as shown in the calibration setup of figure 71-1. Connect the analog delay zero output of the delay measuring set to the Y-axis input of the X-Y recorder. Connect the analog frequency (F) output to the X-axis input of the recorder. Set the delay measuring set for end-to-end loop and calibrate the X-axis of the recorder between 0 and 4 kHz by varying the frequency and adjusting the controls of the recorder accordingly. Then calibrate the Y-axis of the recorder between 0 and 1400 µsec by varying the delay measuring set controls and adjusting the recorder as required.

NOTE: If measuring tandem links where the total delay is the summation of the delay on the individual links, a larger Y-axis spread may be required.

(5) At the transmit end, set the delay measuring set to transmit and connect the output to the input of the circuit or channel to be tested. Adjust the output for 0 or -10 dBm0 for operationsl systems. Adjust the output frequency for 2004 Hz.

(6) At the receive end, connect the channel or circuit output to the input and adjust the delay measuring set to read the trasmitted level.

b. End-to-End without Reference.

(1) Connect the test equipment as shown in figure 71-1. Adjust the delay measuring set controls in accordance with the operating manual.

(2) At the receive end, make vernier synchronization adjustments to the modulation oscillator to stop any drift in the delay reading.

(3) Set the delay to a convenient reference value at 2004 Hz. On some models, this reference may have to be adjusted at the transmit end.

(4) At the transmit end, set the upper and lower frequency limits to 204 to 4004 Hz in accordance with the operating instructions. Select a sweep rate that will not exceed the tracking rate of the X-Y recorder.

(5) Record the delay as described in paragraph 71-5.

c. End-to-End with Return Reference.

(1) Connect the test equipment as shown in figure 71-2.

(2) Set the delay measuring set controls as specified in the operating manual for use of this mode.

(3) Set the transmit and receive ends to 2004 Hz and adjust the delay reference at the transmit end. In this mode, the modulating signal is generated at the transmit end and used to amplitude modulate a carrier whose frequency is controlled and swept at the transmitter.

(4) At the transmit end, set the upper and lower limits on the sweep generator to 204 to 4004 Hz using the operating manual instructions. Select the sweep rate desired.

(5) Record the delay as described in paragraph 71-5.

d. End-to-End with Forward Reference.

(1) Connect the test equipment as shown in figure 71-3. Specific instructions may not be included in operating manuals for this mode. However, delay measuring sets having return reference modes can be configured for forward reference by holding the sweep generator to a single frequecy at the receive end and selecting any desired sweep rate at the transmit end. In this mode, the modulating signal is generated at the receive end where its phase is compared with the phase of the demodulated received signal and also transmitted to the transmit end, over the return modulating signal channel, where it is used to modulate the transmitter.

(2) Set the transmit and receive ends to 2004 Hz and adjust the reference delay at the receive end to some convenient value.

(3) At the transmit end, set the upper and lower limits on the sweep generator to 204 to 4004 Hz using the operating manual instructions. Select the sweep rate desired.

(4) Record the delay as described in paragraph 71-5.

e. Instation Equipment. Measurements are made in the same manner as end-to-end measurements with one delay measuring set acting as both the transmitter and receiver.

(1) Connect the transmit and receive ends to the test points between which the envelope delay distortion is being measured.

(2) Record the delay as described in paragraph 71-5.

71-5. DATA RECORDING AND ANALYSIS.

a. Use a fast sweep for stable transmission paths. If the channel contains abrupt discontinuities or if the transmission path is subject to frequent rapid fades, use a slow sweep to minimize the effect of fades.

b. Turn on the X-Y recorder servos and ensure that the pen reads the reference delay at 2004 Hz on the data sheet. Reduce the frequency until the recorder goes off scale or at least to the 200-µsec point. Turn on the sweep. Record the delay at the transmit end.

c. Allow the sweep to continue until the pen goes off scale or at least to the 2000-µsec point. Raise the pen, turn off the servos, turn off the sweep, and return the frequency to 2004 Hz. Check the delay distortion curve at 2004 Hz. If the curve did not cross the reference delay value at that point, the equipment has drifted and the test must be repeated.

d. Complete the graphs for each channel tested and review the data to determine if it is complete, accurate, and within specified limits. Summarize the test results on figure 3-7 (DD Form 2091).

e. Remove all test equipment and restore the system to its normal configuration.

f. If the channels, circuits, or equipment fails to meet the specified performance requirements, notify the responsible activity of required corrective actions.

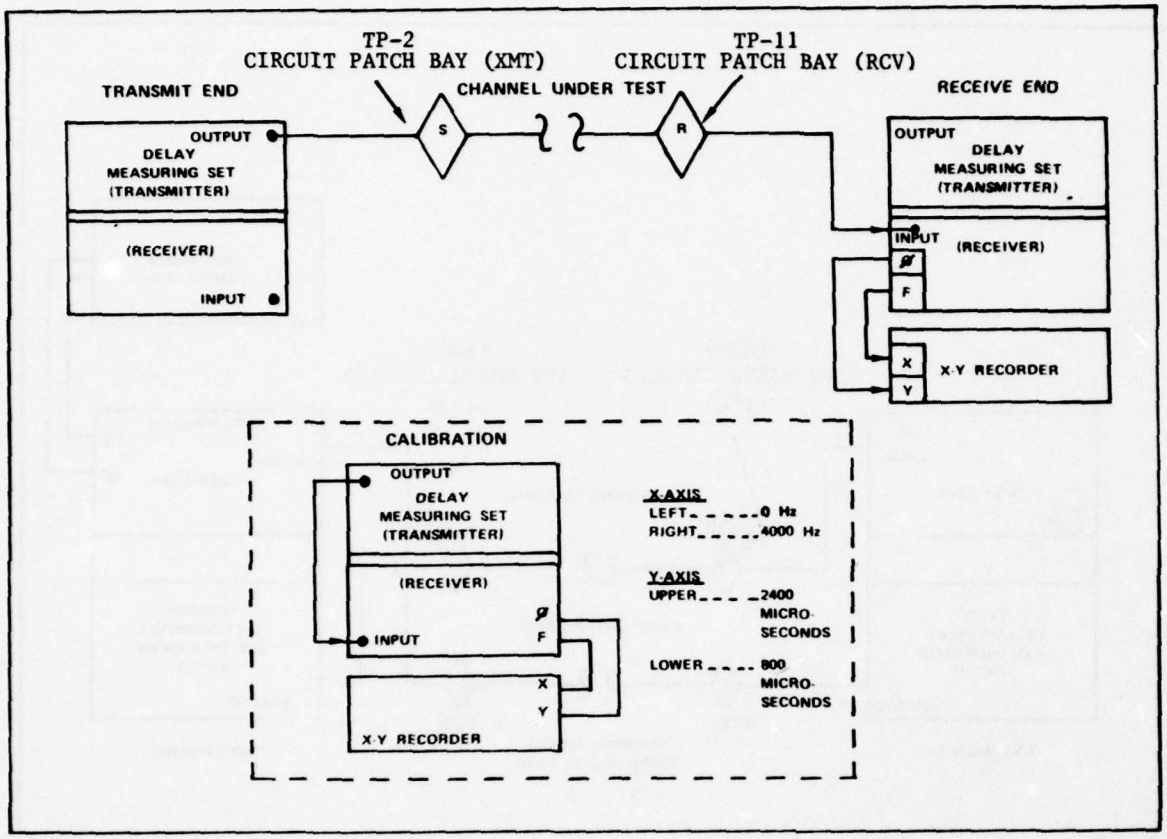


Figure 71-1. Voice channel envelope delay (end-to-end) (automatic) test setup.

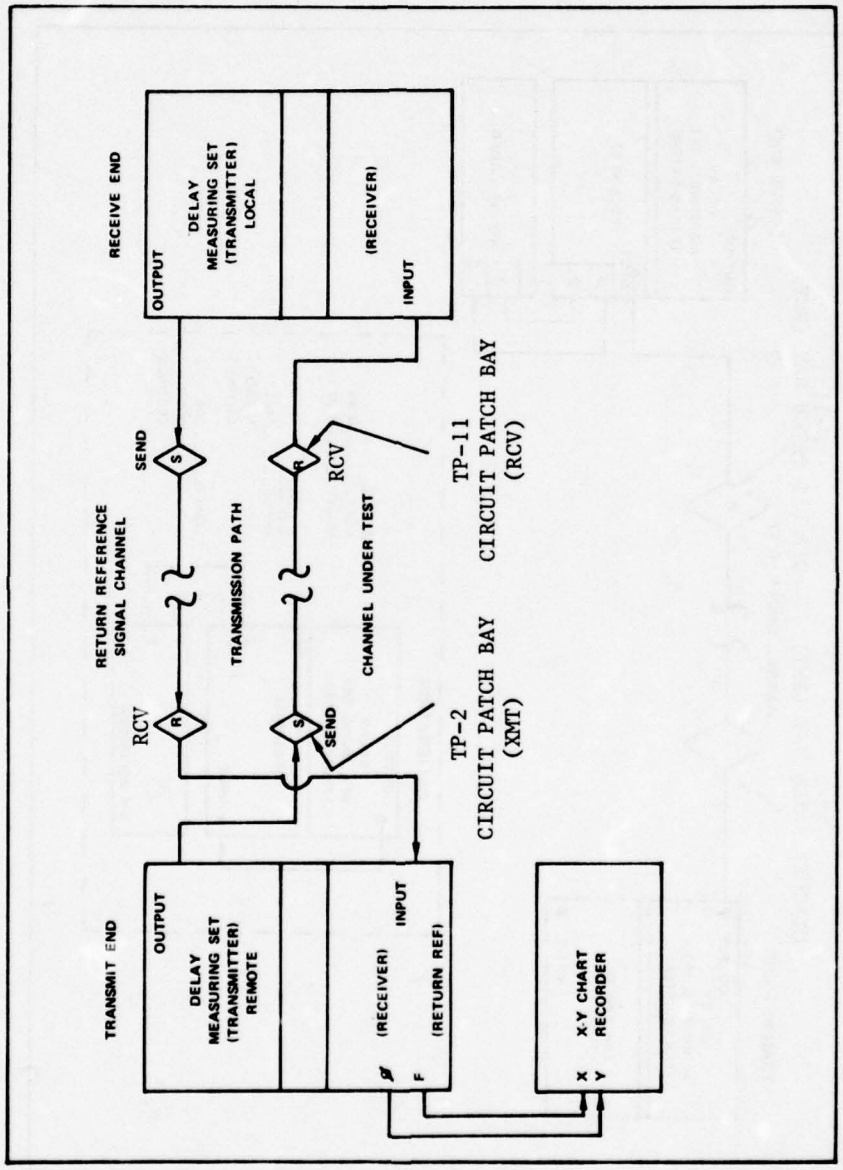
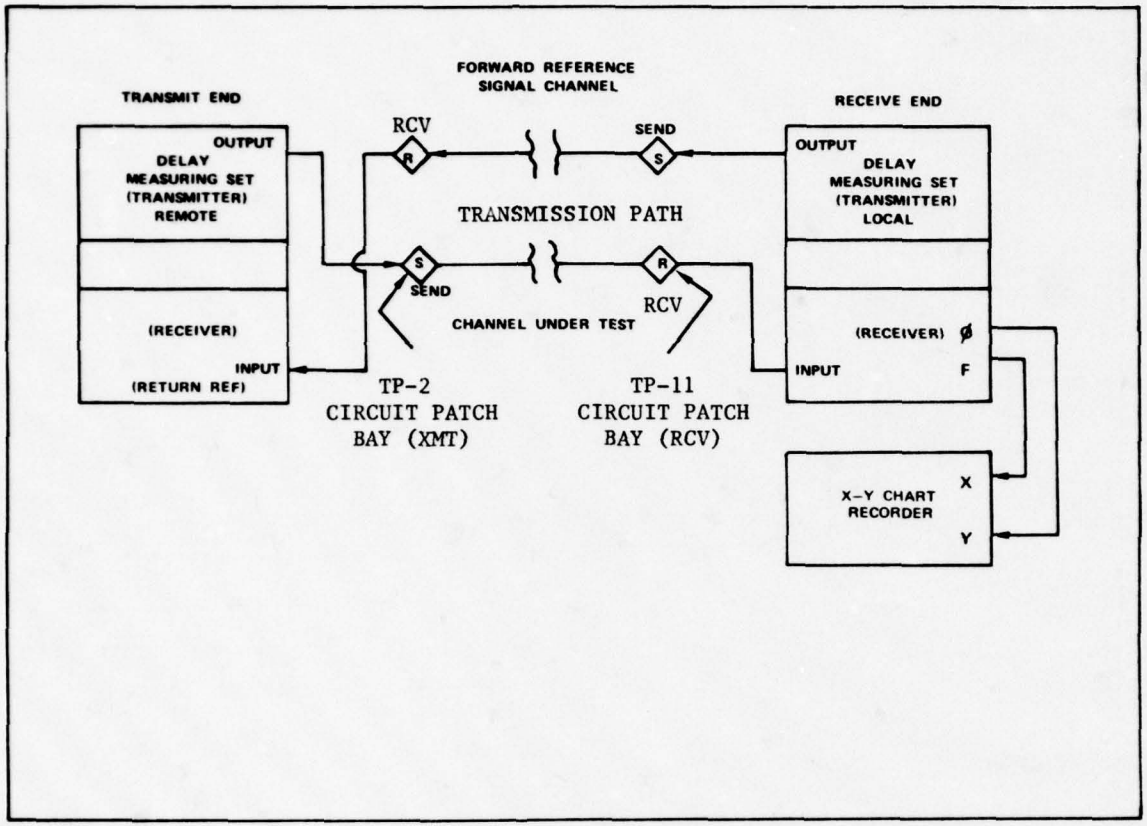


Figure 71-2. Voice channel envelope delay (end-to-end with return reference) (automatic) test setup.



CCP 702-11

Figure 71-3. Voice channel envelope delay (end-to-end with forward reference) (automatic) test setup.

CHAPTER 72

VOICE CHANNEL ENVELOPE DELAY DISTORTION (MANUAL METHOD) (DT-269)

72-1. GENERAL.

a. The purpose of this test is to measure the envelope delay distortion characteristics of individual voice channels, circuits, or equipment using a delay measuring set or a transmission impairment measuring set for manually sweeping the necessary frequency bandwidth of the device under test.

b. End-to-end measurements require the line under test to be measured in one direction only. In some situations, it may be the only method possible. However, the need to establish synchronization between the modulating signal oscillators at both ends, plus time-consuming adjustments requiring voice coordination, make it a less desirable method when other options exists.

c. End-to-end with return reference eliminates the necessity of synchronizing the modulating signal oscillators. Modulation is detected from the receiver amplitude modulated swept carrier at the receive end and applied to an unswept fixed frequency carrier for return to the transmit end where its phase is measured relative to the phase of the modulating signal. This method measures envelope delay in the transmit direction and is particularly useful where measurements are made and recorded primarily at the transmit end. A separate reference return circuit is required.

d. End-to-end with forward reference eliminates the necessity of synchronizing the modulating signal oscillators; however, this option may not be available on all delay measuring sets. In forward reference, a modulating signal from the receive end modulating signal generator is transmitted over a fixed frequency carrier to the transmit end where it modulates the transmitter. The receive end operates in the same manner as for return reference, except that the measurements are made and recorded at the receive end instead of the transmit end. A separate forward reference circuit is required.

e. Envelope delay distortion measurements using delay measuring set can be performed on instation equipment (such as line conditions). These measurements serve as a troubleshooting tool and a quality control check where they can be compared against a known standard. They should never be used for circuit tests.

f. In general, the voice channel envelope delay distortion measurements will be made between the transmit circuit patch bay (TP-2) and the receive circuit patch bay (TP-11). In some cases, conditioning, equipment installed between TP-2 and TP-3 or between TP-10 and TP-11 is adjusted to equalize the channel on a circuit basis; that is, they may be adjusted to compensate for another link working in tandem with the link under test. In such cases, the

equalizers should not be readjusted to provide a flat response over the single link between TP-2 and TP-11. Instead, tests should be performed between TP-3 and TP-10. It may also be necessary to perform the test between other test points to isolate problems.

g. All channels in each 1st level multiplexer should be tested, especially during initial installation. On an operational system it may be desirable to only sample the multiplex channel performance.

h. Repeat the following procedures for all channels to be tested. Reverse the direction of transmission and repeat the tests.

i. This test may be performed on contractor EF&I systems to ensure that they conform to the contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test activities as directed. The number of channels or circuits to be tested will normally be specified. An adequate number of measurements should be made across the frequency spectrum to provide a high degree of confidence that the system performance and installation meet the applicable specifications.

72-2. SPECIFICATIONS.

a. As a design objective, the envelope delay distortion of a long haul TDM/PCM reference voice bandwidth link over the frequency bandwidth from 600 to 3200 Hz shall not exceed 300 µsec. Between 1000 and 2500 Hz, the envelope delay distortion shall not exceed 125 µsec. (MIL-STD-188-100)

NOTE: It is assumed that the envelope delay distortion of PCM/TDM reference links in tandem is the sum of the envelope delay distortion contributed by the single links.

b. The envelope delay distortion of a TD-1192 (AN/FCC-98) shall not exceed 400 µsec in the frequency band between 500 and 3000 Hz and shall not exceed 175 µsec in the frequency band between 1000 and 2500 Hz. (CCC 74047)

c. The following criteria applies to the TSEC/CY-104 used as part of the European digital equipment upgrade.

(1) The design objective for the envelope delay distortion shall not exceed 300 µsec in the frequency band of 600 to 3200 Hz and shall not exceed 125 µsec in the frequency band of 100 to 2500 Hz.

(2) Typically, the VICOM terminal equipment shall be capable of meeting the D2 requirements which are:

FREQUENCY (0-dBm0 tone) (Hz)	DELAY (µsec)
1150 to 2300	120
1000 to 2500	170
800 to 2700	235

d. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

72-3. TEST EQUIPMENT REQUIRED.

a. Delay measuring set or transmission impairment measuring set.

b. Oscilloscope.

72-4. TEST PROCEDURES.

a. General.

(1) Complete the top portion of figure 16-4 (DD Form 2095). Modify the data sheet to include 1st and 2d level multiplexers. At the transmit and receive ends, measure and record the PCM/TDM composite signal level of the multiplex/demultiplex input/output. In the 1st column of the data sheet, following the frequency, enter the relative delay and in the 2d column enter the delay as normalized to the referenced delay for each channel.

(2) Connect the test equipment as shown in figure 72-1 and allow approximately 30 minutes for warmup and stabilization.

(3) Adjust the measuring set input/output impedance to 600 ohms if testing at the VF channel level, circuit patch bay, or at the VFPB. For balanced operation, remove all shorting straps which may be placed between one side of the input line and ground. Switch the measuring set to 83-1/3-Hz modulation.

NOTE: Frequencies shown in figure 16-4 (DD Form 2095) should be offset from multiples of 100 to preclude interaction with the 8000-Hz sampling rate on TDM/PCM equipment.

(4) At the transmit end, set the measuring set to transmit. Connect the output to the line, circuit, or equipment to be tested. Normally, the test will be conducted at the circuit patch bay (TP-2); however, if line conditioning equipment is inserted between the circuit patch bay (TP-2) and VFPB (TP-3), this equipment will have to be bypassed. If testing the equipment to specifications, the test will be performed directly at the voice frequency channel input and output. Adjust the output frequency to 2004 Hz at a level of 0 or -10 dBm0 if testing an operational system.

(5) At the receive end, connect the output of the circuit or channel to the receiving measuring sets 600-ohm input. Adjust to read the frequency and level of the transmitted tone.

(6) The measured received tone should be within ±0.25 dB. If not, aline the channel/circuit.

b. End-to-End without Reference.

(1) Adjust the controls as outlined in the instruction manual and connect the test equipment as shown in figure 72-1.

(2) At the receive end, adjust the vernier synchronization to the modulation oscillator to stop any drift in the delay reading.

(3) Set the delay to some convenient reference value at 2004 Hz. On some models this reference must be adjusted at the transmit end.

(4) Adjust the transmit end to 204 Hz. Record the delay at the receive end.

(5) Increase the frequency at the transmit end in the frequency increments shown on the data sheet. Record the delay readings in the appropriate column.

(6) Plot the readings from the data sheet on figure 3-4 (DD Form 2094).

c. End-to-End with Return Reference.

(1) Connect the test equipment as shown in figure 72-2. Specific instructions for use of this mode are included in operating manuals for various measuring sets. Controls should be set as per instructions for transmit and receive ends.

(2) Set the transmit and receive ends to 2004 Hz. Adjust the delay reference for some convenient value at the transmit ends. In this mode the modulating signal is generated at the transmit end and used to amplitude modulate a carrier whose frequency is controlled and swept at the transmitter.

(3) At the transmit end, adjust the measuring set to 204 Hz and record the delay at the receive end on the data sheet.

(4) Increase the frequency at the transmit end in the increments shown on the data sheet. Record the delay readings in the appropriate column at the receive end.

(5) Plot a curve of envelope delay versus frequency on figure 3-4 (DD Form 2094).

d. End-to-End with Forward Reference.

(1) Connect the test equipment as shown in figure 72-3.

(2) Specific instructions may not be included in operating manuals for this mode. However, measuring sets having return reference modes can be configured for forward reference by holding the sweep generator to a single frequency at the receive end and manually setting the desired frequency at the transmit end. In this mode, the modulating signal is generated at the receive end where its phase is compared with the phase of the demodulated received signal. The signal is also transmitted to the transmit end, over the return modulating signal channel, where it is used to modulate the transmitter.

(3) Set the transmit and receive ends to 2004 Hz and adjust the reference delay at the receive end to some convenient value.

(4) Adjust the transmit end to 204 Hz and record the delay at the receive end on the data sheet.

(5) Increase the frequency at the transmit end in the increments shown on the data sheet. Record the delay readings in the appropriate column at the receive end.

(6) Plot a curve of envelope delay versus frequency on figure 3-4 (DD Form 2094).

e. Instation Equipment. Measurements are made in the same manner as end-to-end measurements with one measuring set acting as both the transmitter and receiver.

(1) Connect the transmit and receive ends to the test points between which the envelope delay distortion is being measured.

(2) Adjust the measuring set to 2004 Hz and the delay reading to some convenient value.

(3) Change the frequency to 204 Hz and record the delay on the data sheet.

(4) Increase the frequency in the increments shown on the data sheet. Record the delay readings in the appropriate column.

(5) Plot a curve of envelope delay versus frequency on figure 3-4 (DD Form 2094). Include all channels out of specifications.

72-5. DATA RECORDING AND ANALYSIS.

a. Record all data on figure 16-4 (DD Form 2095). Using the recorded data, plot a curve of envelope delay versus frequency on figure 3-4 (DD Form 2094). To aid in the data analysis, prepare an overlay of the specifications and use the overlay to determine if the channel meets specifications.

b. Remove all test equipment and restore the system to its normal configuration.

c. If a system or channel fails to meet specified requirements, notify the responsible activity of required corrective actions.

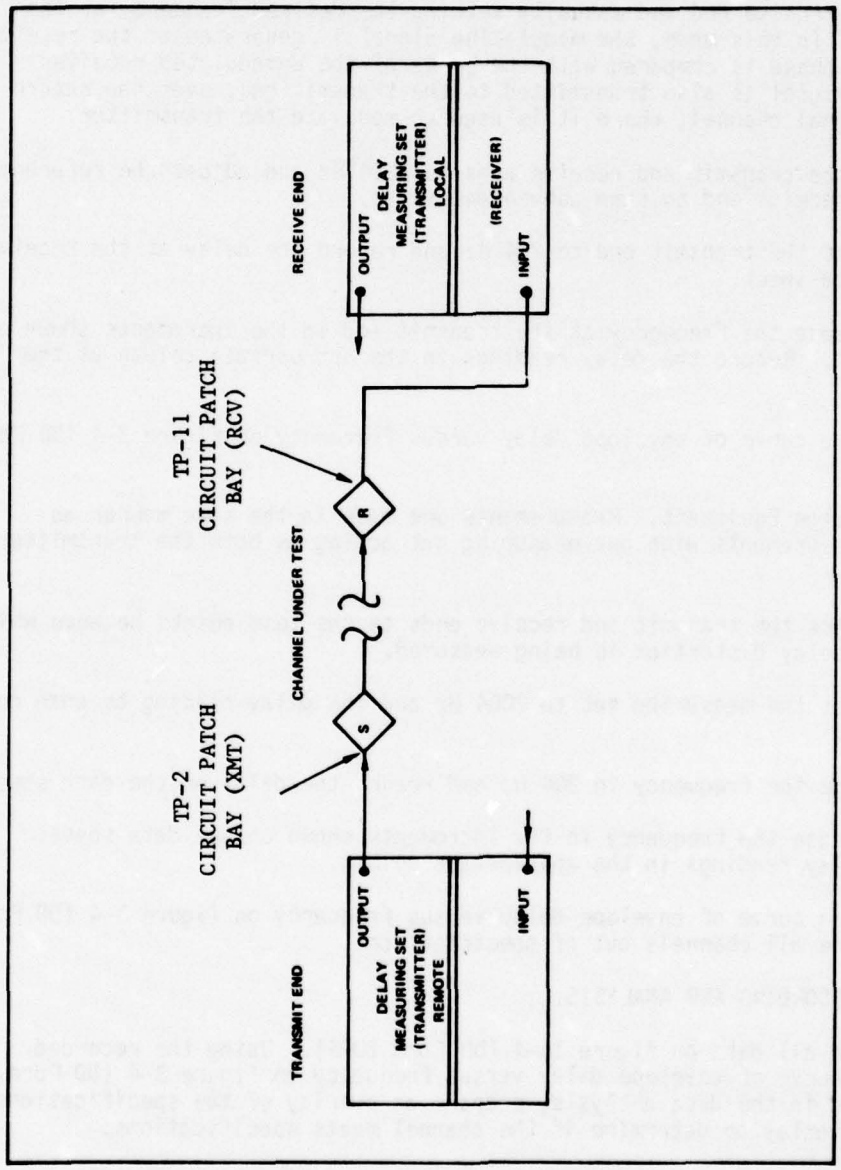


Figure 72-1. Voice channel envelope delay (end-to-end) (manual) test setup.

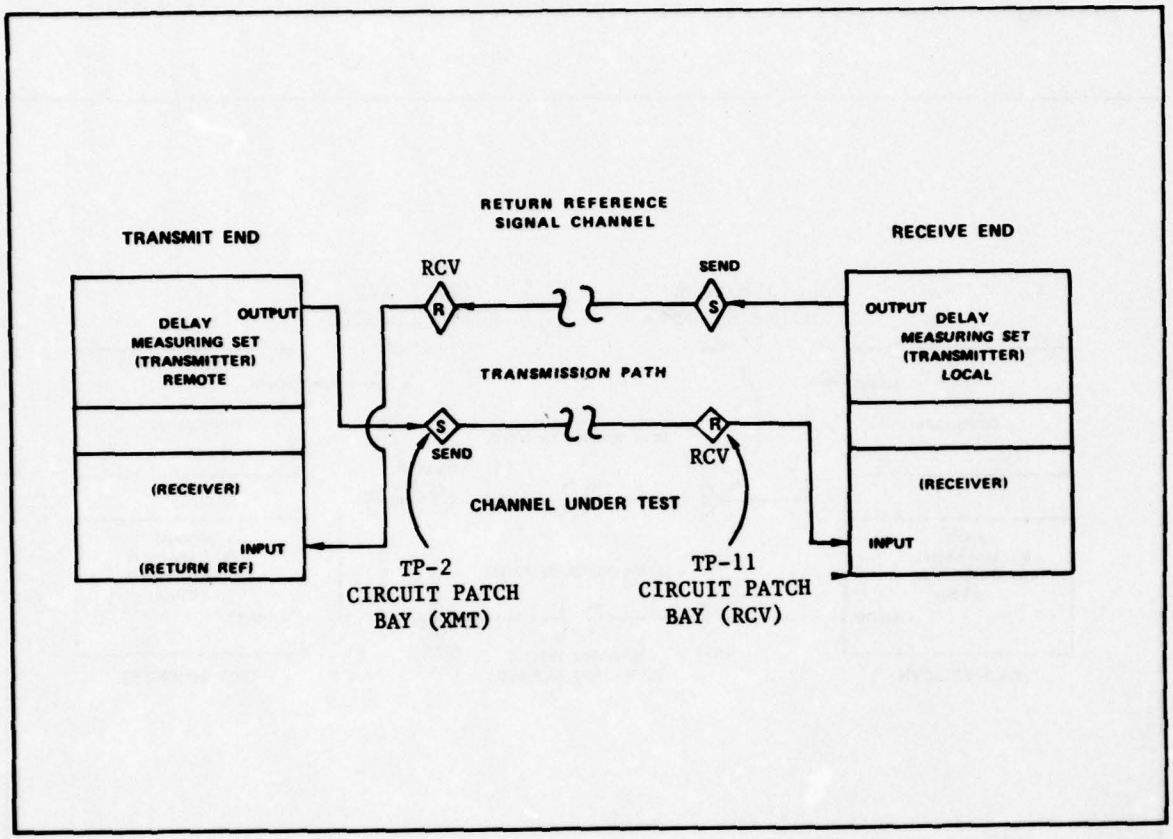


Figure 72-2. Voice channel envelope delay (end-to-end with return reference) (manual) test setup.

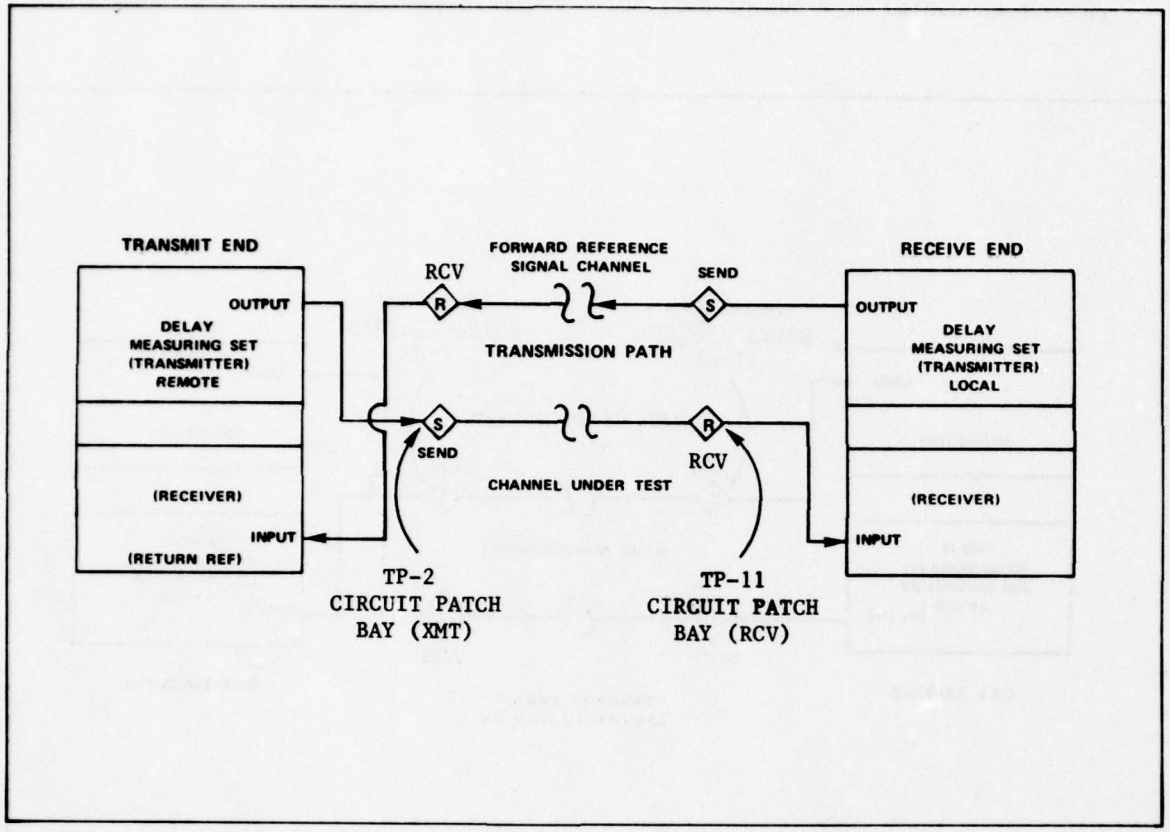


Figure 72-3. Voice channel envelope delay (end-to-end with forward reference) (manual) test setup.

CHAPTER 73

VOICE CHANNEL INTERMODULATION DISTORTION (DT-270)

73-1. GENERAL.

a. The purpose of this test is to measure the amount of nonlinear distortion in a voice frequency channel/circuit or other equipment when two pairs of closely spaced frequencies are transmitted through the channel.

b. Intermodulation distortion is the degradation of a complex signal caused by nonlinear characteristics at one or more points along the transmission system. It is characterized by the formation of frequencies in the output of the system equal to the sums and differences of integral multiples of the basic component frequencies present at the input. Harmonic components are also present in the circuit but are usually not included as part of the intermodulation distortion.

c. As outlined above, the nonlinear characteristics of the channel that produce the distortion cause new frequencies to be generated. The level of these frequencies relative to the level of the original signal frequencies provides a measure of the distortion produced in the channel. These new frequencies are known as distortion products. When a single frequency signal is transmitted, the distortion products are harmonically related to the signal; that is, they are integral multiples of the frequency transmitted. When a signal consisting of two or more frequencies is transmitted, there are other products developed called intermodulation products. These intermodulation products are the result of the modulation of each of the frequencies by each of the other frequencies. Since harmonics are also present and contribute to the generation of intermodulation products, it can be seen that the number of new frequencies produced by intermodulation when a complex signal is transmitted is almost infinite.

d. Practical measuring methods include measurements of 2d and 3d order products. The order of the product is the sum of the coefficient of the terms in the frequency expression for the two frequencies producing the product. For example, if two frequencies (F1 and F2) are transmitted, 2d order products would be F1 + F2 and F1 - F2 or F2 - F1. Third order products would be 2F1 + F2, 2F1 - F2, 2F2 - F1, and 2F2 + F. Fifth order products would be 3F1 - 2F2, 2F2 - 2F1, and similar combinations.

e. This test may be performed using a nonlinear distortion test set as shown in figure 73-1 or by using test oscillators as shown in figure 73-2. The measurement is much simplified if using the nonlinear distortion test set since the two test frequencies are contained within one unit. The frequencies used by the test set are 860 and 1380 Hz (para 73-3a).

f. This test would normally be performed at the circuit patch bay when testing overall circuit performance and directly at the multiplex/demultiplex channel input/output when testing equipment to specifications.

g. This test may be performed on contractor EF&I systems to ensure that they conform to the contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

73-2. SPECIFICATIONS.

a. The individual inband intermodulation products of a TD-1192 (AN/FCC-98) within the band of 300 to 3400 Hz produced by any two equal level tones introduced at a -3 dBm0 in that band shall be no greater than -38 dBm0. (CCC 74047)

b. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

c. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specification.

73-3. TEST EQUIPMENT REQUIRED.

a. Nonlinear distortion test set or transmission measuring set.

b. AC voltmeter.

c. Oscilloscope.

d. Frequency counter.

e. Frequency selective voltmeter.

73-4. TEST PROCEDURES. Each VF channel will be tested using the procedures described below. The direction of measurement will then be reversed and the test repeated for each channel.

a. Nonlinear Distortion Test Set.

(1) Connect the test equipment as shown in figure 73-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Set up the test set to measure nonlinear distortion in accordance with the equipment instruction manual.

(3) At the transmit end, adjust the output level for -3 dBm0 if testing TD-1192 (AN/FCC-98) and -10 dBm0 for operational systems.

(4) At the receive and transmit ends, measure the composite data level of the 1st and 2d level multiplex input and demultiplex output with the oscilloscope. Record this level on figure 73-3 (USACC Form 661-R).

(5) At the transmit end, transmit the composite tone level as in subparagraph (3), above. At the receive end, depress the signal level pushbutton and observe the level of the transmitted signal.

(6) At the receive end, engage the 2d order pushbutton and read the 2d order distortion on the meter display. Record this value on the data sheet.

(7) Set the meter to read the 3d order products and record this value on the data sheet.

b. Test Oscillators.

(1) Connect the test equipment as shown in figure 73-1 and ensure that the transformer output matches the channel input impedance.

(2) At the transmit end, connect the two oscillators and resistive network as shown in figure 73-2. Adjust oscillator 1 to 860 Hz and oscillator 2 to 1380 Hz.

(3) Connect point C to a 600-ohm resistor and set the level of the 860- and 1380-Hz tones so that the combined output is equal to -3 dBm0 for the TD-1192 (AN/FCC-98) equipment or -10 dBm0 for operational systems. A 0-dBm0 composite level should be used whenever there is no possibility of interfering with system traffic.

(4) Connect the frequency selective voltmeter to point C and measure the intermodulation products at 520 Hz (B - A), 2240 Hz (A + B), and 1900 Hz (2B - A). Each harmonic originating in the test equipment should be at least 50 dBm0 (preferably 60 dBm0) to provide valid test results.

(5) After the -50 dBm0 equipment performance has been determined, disconnect the frequency selective voltmeter and the 600-ohm termination.

(6) At the transmit end, insert the composite tones into the channel under test at the circuit patch bay, VFPB, or directly into the channel depending on test requirements, at the level established in subparagraph (3), above.

(7) At the receive end, connect the frequency selective voltmeter (600-ohm termination) to the output of the channel under test at the circuit patch bay. If required for impedance matching of the frequency selective voltmeter to the test point, use an impedance matching transformer.

(8) At the receive end, tune the frequency selective voltmeter to the frequencies shown on the data sheet and measure the levels in dBm and dBm0 for each frequency. Record this information on the data sheet.

(9) If the distortion is measured in mV calculate the intermodulation distortion using the following formula:

(a) $ID = \sqrt{\frac{E_{520}^2 + E_{1900}^2 + E_{2240}^2}{E_{860}^2 + E_{1380}^2}} \times 100 \text{ percent}$

(b) Use figure 73-4 for adding two powers expressed in dBm. The dB difference in the two power values is noted on the abcissa of the figure, and the corresponding delta is found from the graph. The delta value is then added to the larger of the two original powers to obtain the sum. A list of powers can be summed two at a time by this method. A distortion conversion graph is shown in figure 73-5.

73-5. DATA RECORDING AND ANALYSIS.

a. Record all test results on the data sheet and review the test data for compliance to the specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the channels, circuits, or equipment fail to meet specified requirements, notify the responsible activity of required corrective actions.

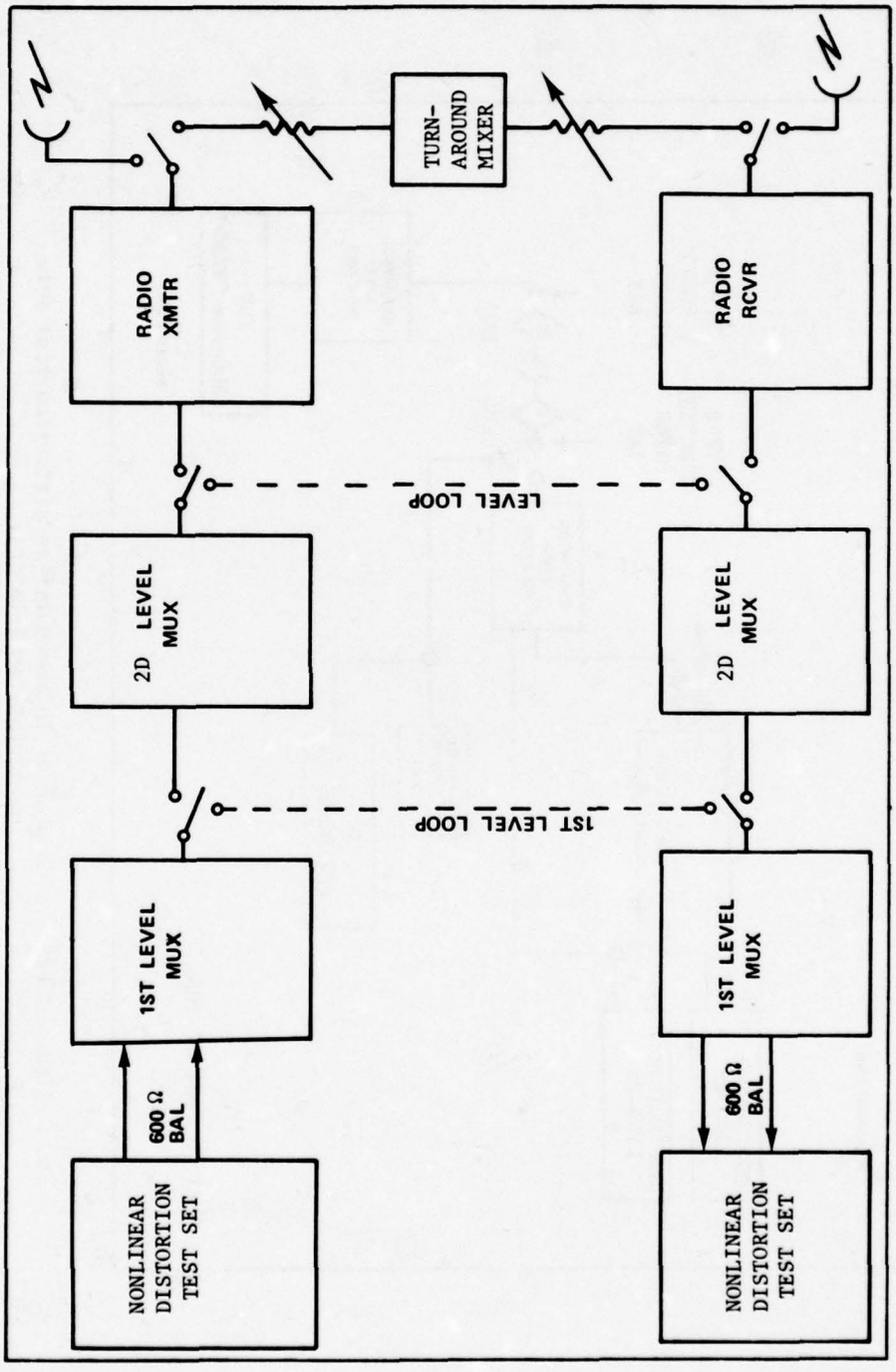


Figure 73-1. Voice channel intermodulation distortion test setup using a nonlinear distortion test set.

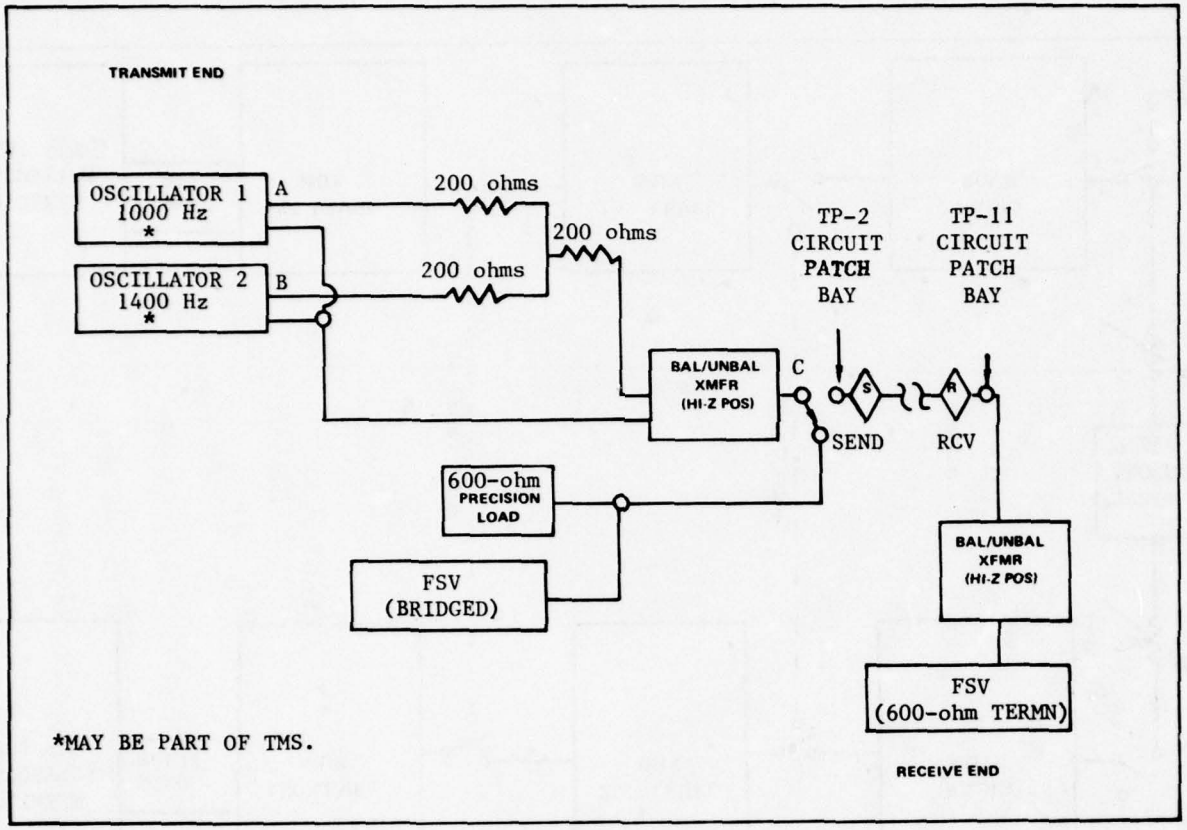


Figure 73-2. Voice channel intermodulation distortion test setup using test oscillators.

VOICE CHANNEL NONLINEAR DISTORTION (CCR 702-1-3) DATA SHEET				PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION		TEST ENGINEER
TEST POINTS AND LEVELS ▶	TRANSMIT VF TP ____ ____dBm 1st LVL MUX ____VPP 2d LVL MUX ____VPP	RECEIVE VF TP ____ ____dBm 1st LVL MUX ____VPP 2d LVL MUX ____VPP		TRANSMIT COMPOSITE LEVEL dBm ____ dBm0 ____

PORT/CHANNEL			RECEIVE TEST SIGNAL LEVELS						INTERMODULATION COMPONENTS						
			860 Hz			1380 Hz			520 Hz		1900 Hz		2240 Hz		
1ST LVL MUX	2D LVL MUX	CHAN	dBm	dBm0	mV	dBm	dBm0	mV	dBm	mV	dBm	mV	dBm	mV	PERCENT DISTORTION

USACC FORM 661-R
1 MAY 79

Figure 73-3. Voice channel nonlinear distortion data sheet.

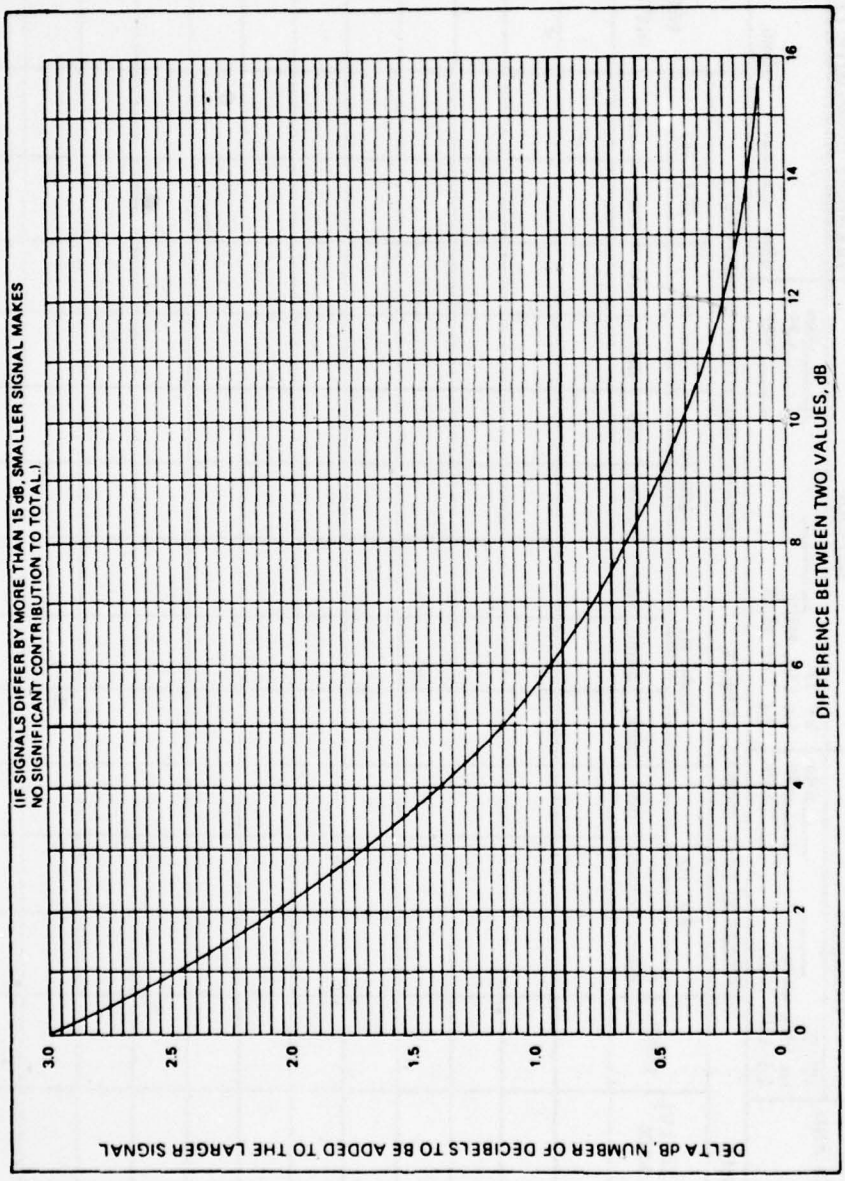
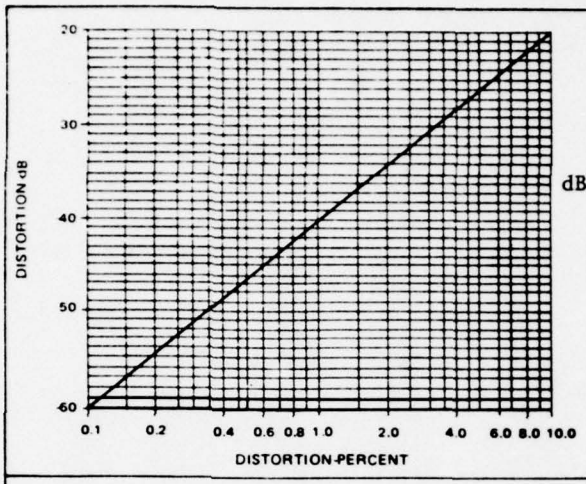


Figure 73-4. Graph for adding signals expressed in dB.



$$\text{dB DISTN} = 20 \text{ LOG} \left(\frac{\%\text{DISTN}}{100} \right)$$

dB	PERCENT	dB	PERCENT
-20	10.0	-37.5	1.35
-21	9.0	-38	1.27
-22	8.0	-38.5	1.2
-23	7.1	-39	1.12
-24	6.4	-39.5	1.06
-25	5.7	-40	1.0
-26	5.0	-40.5	0.95
-27	4.5	-41	0.90
-28	4.0	-41.5	0.85
-29	3.6	-42	0.80
-30	3.2	-42.5	0.75
-30.5	3.0	-43	0.71
-31.0	2.85	-43.5	0.67
-31.5	2.67	-44	0.64
-32	2.55	-44.5	0.60
-32.5	2.4	-45	0.56
-33	2.25	-46	0.50
-33.5	2.15	-47	0.45
-34	2.0	-48	0.40
-34.5	1.9	-49	0.35
-35	1.8	-50	0.32
-35.5	1.69		
-36	1.6		
-36.5	1.5		
-37	1.41		

Figure 73-5. Conversion of dB distortion to percent distortion.

CHAPTER 74

VOICE CHANNEL HARMONIC DISTORTION (DT-271)

74-1. GENERAL.

a. The purpose of this test is to measure and evaluate the amount of harmonic distortion in a voice frequency channel or other equipment by measuring the level of harmonically related frequencies when a single frequency signal is transmitted through the channel. Methods are described for measuring single and total harmonic distortion of audio frequency signals sent over a physical circuit or multiplexed transmission system. The test my also be performed on any individual part of the audio system providing the input and output frequencies are in the same audio range.

b. The harmonic distortion in a voice frequency channel arising from nonlinearity of its gain characteristics is predominantly of the 2d order category which will vary approximately as the square of the test tone level. The signal source used for testing must have low harmonic distortion if accurate results are to be obtained.

c. If a pure, single frequency test signal from an oscillator is applied at the desired level to the system under test, any harmonics generated within the system due to its nonlinearity will appear at its output together with the test signal (which is the fundamental or 1st harmonic). The single harmonic distortion (for any single harmonic) is the ratio of the fundamental frequency to the power at the harmonic frequency expressed in dB. The total harmonic distortion is the ratio of the power at the fundamental frequency to the sum of the powers at all the harmonic frequencies (usually only the 2d and 3d harmonics) expressed in dB.

d. This test may be performed on contractor EF&I systems to ensure that they conform to the contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed. The number of channels or circuits to be tested will normally be specified. An adequate number of measurements should be made across the frequency spectrum (if multiplexed) to provide a high degree of confidence that the system's performance and installation meet the applicable specifications.

74-2. SPECIFICATIONS.

a. As a design objective, the total harmonic distortion of any audio channel of a long haul TDM/PCM reference voice bandwidth link produced by any single frequency test signal within the frequency band between 300 and 3400 Hz shall be at least 34 dB below the demultiplexer output signal level. The test signal shall be introduced into the link at a level of 0 dBm0. (MIL-STD-188-100)

b. The level of any single harmonic product of the TD-1192 (AN/FCC-98) produced by any single 0-dBm0 test tone frequency, within the band of 300 to 3400 Hz, shall be at least 40 dB below reference (-40 dBm0). (CCC-74047)

c. The level of any single harmonic product of the AN/FRC-162 and VICOM 4000-2 system produced by any single 0-dBm0 test tone frequency, within the band of 0 to 12 kHz, shall be at least 28 dB below reference (-28 dBm0).

d. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplexer/demultiplexer equipment shall operate as specified in the standard engineering plan or contract specifications.

74-3. TEST EQUIPMENT REQUIRED.

a. Distortion analyzer.

b. Frequency selective voltmeter or wave analyzer.

c. Balanced/unbalanced transformer.

d. Transmission measuring set.

e. AC voltmeter.

74-4. TEST PROCEDURES.

a. Complete the top portion of figure 74-1 (DD Form 2112) modifying the form as necessary to include 1st and 2d level multiplexers and proper frequencies.

b. Set up the test equipment for calibration as shown in figure 74-2 and allow approximately 30 minutes for warmup and stabilization.

c. At the transmit end, proceed as follows for calibration of the equipment.

(1) Connect the audio oscillator and AC voltmeter to a 600-ohm terminated, balanced/unbalanced transformer. If the test is being performed at a test point other than 600 ohms (balanced) set the equipment to the impedance of the test point to be used for the test.

(2) Connect the distortion analyzer input to the other side of the balanced/unbalanced transformer.

(3) Adjust the oscillator to 704 Hz and set the output level to 0 dBm0 as read on the AC voltmeter, if the test is being performed at the circuit patch bay. If the test is to be performed at a test point other than the circuit

patch bay, adjust the oscillator output to correspond to the design level of the equipment where the test is to be performed. As an example, if the design level at the VFPB is -16 dBm, then the output of the oscillator should be adjusted accordingly.

(4) Measure the distortion of the oscillator by setting a reference level on the distortion analyzer meter, notching out the 704-Hz tone, and reading the total harmonic distortion in dB. To successfully conduct this test, the oscillator distortion should be at least 50 dB and preferably 60 dB below the reference level. If the oscillator does not meet this requirement, another oscillator should be obtained. If another oscillator is not available, try using a narrow bandpass filter on the output of the oscillator. Adjust the oscillator to the center frequency of the bandpass filter. Do not conduct this test with a center frequency of over 1004 Hz.

d. At the transmit end, connect the output of the oscillator through the balanced/unbalanced transformer (high impedance position) to the channel input at the circuit patch bay. Monitor the level set at 0 dBm0 with the AC voltmeter connected through a balanced/unbalanced transformer (high impedance position) to the circuit patch bay as shown in figure 74-2.

e. At the receive end:

(1) Connect the output of the channel (TP-11) to the balanced side of the 600-ohm terminated, balanced/unbalanced transformer.

(2) Connect the unbalanced side of the transformer to the bridged input of the distortion analyzer and the frequency selective voltmeter.

(3) The received 704-Hz tone should be within ±1 dB of the 0-dBm0 reference tone being transmitted from the distant end of the circuit.

(4) Measure the total distortion in the circuit by setting a dB reference level on the distortion analyzer voltmeter, notching out the 704-Hz tone and reading the total harmonic distortion in dB. Record the reading on the data sheet.

(5) Compute and record the corresponding percentage of distortion using figure 73-5.

(6) Measure and record the distortion at the harmonically related frequencies of 1408, 2112, and 2816 Hz.

(7) If the measured distortion is greater than -40 dB (1 percent), instruct the transmit end to disconnect the tone input and insert a 600-ohm termination into the circuit. Without resetting the analyzer reference level, check for residual noise on the circuit which should be at least 10 dB below the distortion level.

(8) If the measured distortion is significantly greater than -40 dB or if it departs from the established specifications, examine the channel spectrum with a wave analyzer or frequency selective voltmeter. Also, look for and record other spurious frequencies (greater than 50 dBm0) such as carrier leakage, ringing signals, and powerline frequency multiples.

f. To measure the harmonic distortion at a single frequency, the preceding principles apply except that the frequency selective voltmeter or wave analyzer must be tuned successively to the harmonically related frequencies of the fundamental. To measure the distortion at a single frequency:

(1) At the transmit end, adjust the oscillator for 704 Hz (or any other specified frequency) at an output level of 0 dBm as read on the AC voltmeter provided the tone is being inserted at a 0-dBm0 point. If at some other test point, adjust the output level to correspond to the equipment input design level.

(2) At the receive end, tune the frequency selective voltmeter or wave analyzer to 704 Hz. Measure and record the received tone level of the 704-Hz signal. Successively tune the frequency selective voltmeter to the harmonically related frequencies of 1408, 2112, 2816, 3520 Hz, etc. Measure and record the level as read on the frequency selective voltmeter or wave analyzer. The single harmonic distortion (for any single harmonic) is the ratio of the fundamental frequency (704 Hz) to the power at the harmonic frequency expressed in dB. The percent distortion can be obtained from figure 73-5.

g. Instation equipment tests can be performed in the same manner as those described above for channels or circuit tests. However, the equipment must be looped at the multiplexer or demultiplexer input/output and the signal input level must be adjusted to correspond to the equipment design level at the point where the tone is inserted. Care must also be exercised to ensure that the test equipment impedance properly matches the design impedance of the equipment to be tested.

h. Reverse the direction of measurement and repeat the above procedures for each voice frequency channel to be tested.

74-5. DATA RECORDING AND ANALYSIS.

a. Carefully examine the test data for any departures from the established specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system, circuit, channel, or equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

VOICE CHANNEL HARMONIC DISTORTION

PAGE _____ OF _____ PAGES

DATE

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

TEST POINTS AND TLP LEVELS ▶	TP # _____ _____ dBm	TP # _____ _____ dBm	TEST SIGNAL = 0 dBM0

CHANNEL			DISTORTION ANALYZER					DISTORTION ANALYSIS (FREQ. SEL. Vm.)							
			RECEIVE TEST SIG. LEVEL		MEASURED DISTORTION		RESID-UAL NOISE	FREQUENCY, Hz							
								1400	2100	2300					
SG	GP	CH	dBm	ERROR dB	dB	%	dB	LEVEL dBm	LEVEL dBm	LEVEL dBm	FREQ. Hz	LEVEL dBm	FREQ. Hz	LEVEL dBm	FREQ. Hz	LEVEL dBm	PERCENT DIS-TORTION

DD FORM 1 SEP 77 2112

Figure 74-1. Harmonic distortion data sheet.

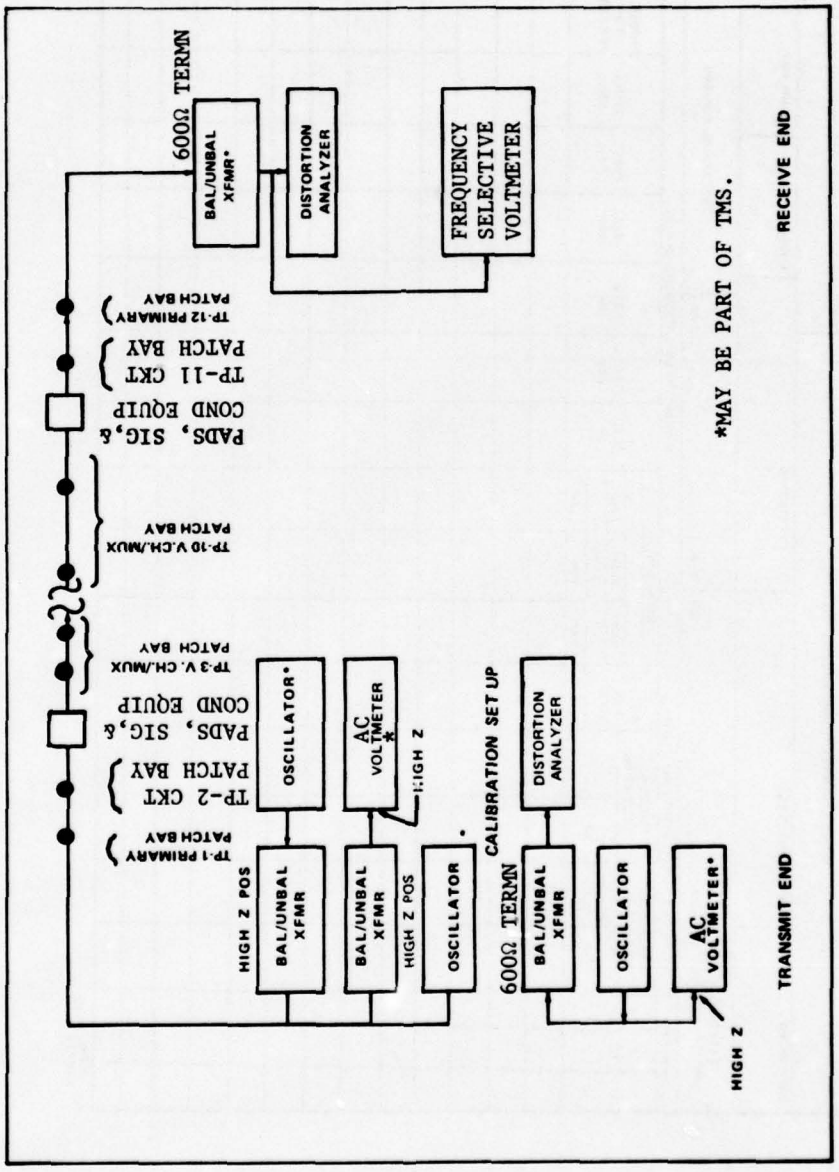


Figure 74-2. Voice channel harmonic distortion test setup.

CHAPTER 75

CIRCUIT NOISE AND SINGLE TONE INTERFERENCE (DT-272)

75-1. GENERAL.

a. The purpose of this test is to measure the total circuit noise and single tone interference on a voice frequency circuit.

b. Although these procedures basically duplicate DT-270 and DT-271, at times, it may be desireable to use this test so that the measured single tone interference can be compared to the appropriate specification.

c. Total circuit noise includes both basic noise (fluctuating noise), hum, carrier leak, and the interference (crosstalk, intermodulation) arising from other traffic carried on the system.

d. The interfering effect of noise on a telecommunications circuit is fairly well described by a measurement of noise power level which is specially weighted to account for the characteristics of the telephone set, the voice frequency circuit, and the human ear. The required attenuation/frequency characteristics of weighting networks have been developed by subjective tests. The two principal weighting networks commonly used are flat and C-message. To measure the total circuit noise, the noise measuring set must be operated in the flat mode since the C-message weighting will attenuate the low frequency components. These low frequency components normally are not detrimental to user communications since the channel filters will normally not pass such low frequencies. However, measurement of these components will detect problems with shielding, grounding, and bonding within an installation. Under certain conditions, these low frequencies can be detrimental to the user if developed on the tail segments of the circuit.

e. This test may be performed on contractor EF&I systems to ensure that they conform to contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test activities as directed. The number of channels or circuits to be tested will normally be specified; however, an adequate number of measurements should be made across the baseband spectrum to provide a high degree of confidence that the system performance meets specifications.

f. Generally, this test will be performed at the circuit patch bay; however, it can also be performed at additional test points within the system to isolate a problem source.

75-2. SPECIFICATIONS.

a. With a 0-dBm0 test tone on the TD-1192 (AN/FCC-98) at any frequency between 1 and 12,000 Hz (except 300 to 3400 Hz) applied to the four-wire voice frequency input, the output power at any other frequency shall not exceed -30 dBm0 except at 8000 Hz where the output power shall not exceed -45 dBm0. (CCC-74047)

b. There is no documented specification for the AN/FRC-162 and VICOM 4000-2 system; however, it should meet the D2 terminal requirements of not less than -28 dBm0 between 0 and 12,000 Hz with a 0-dBm0 input signal.

c. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

d. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

75-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set or transmission impairment measuring set.

b. AC voltmeter.

c. Frequency selective voltmeter or wave analyzer.

d. Spectrum display unit.

e. Balanced/unbalanced transformer (as required).

75-4. TEST PROCEDURES.

a. At the transmit end, connect the test equipment for calibration as shown in figure 75-1 and allow approximately 30 minutes for warmup and stabilization.

b. With the oscillator output terminated into a 600-ohm precision resistor, tune the oscillator to 1020 Hz and adjust the output signal level for 0 dBm. The AC voltmeter must be placed in the bridging mode when setting the oscillator output level.

c. Connect the oscillator output to the circuit patch bay, the VFPB, or the channel under test as shown in figure 75-1 or 75-2.

d. At the receive end, measure and record the received test tone level on figure 74-1 (DD Form 2112). If the received tone varies more than ±0.25 dB from the reference test tone level, aline the channel or consider the difference in the received level versus the transmitted tone level during the final test results.

e. At the transmit end, remove the test tone and terminate the channel/circuit under test into 600 ohms. At the receive end, connect the noise measuring set (flat weighting) to the channel under test and place the noise measuring set in the 600-ohm terminate mode, balanced operation. Measure and record the noise level referenced to the test point level.

f. The single tone interference can be detected by terminating the channel under test and observing the noise spectrum with a wave analyzer or frequency selective voltmeter and spectrum display unit.

g. At the receive end, measure the single tone interference by maximizing the scale indication of the frequency selective voltmeter or wave analyzer at the disturbing frequency(ies).

h. Convert the measured value in dBm to dBrncO as follows:

$$dBrn = 90 + dBm$$

NOTE: To convert to other units of measure, use table 75-1. As an example, to convert to dBrnc:

FSV reading = 55 dBm at 600 Hz

$$dBrn = 90 \curvearrowright (-55) = 35 \text{ dBrn}$$

$$dBrn = 35 \text{ dBrn} - 5 \text{ dB (600 Hz)} = 30 \text{ dBrnc}$$

i. Reverse the direction of transmission and repeat the procedure for the voice frequency channels in the opposite direction.

75-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the channel/circuit fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

Table 75-1. Noise Unit Conversion Chart

dBrncO	dBaO	PWpO	dBmOp	S/N dB	dBrncO	dBaO	pWpO	dBmOp	S/N dB
0	-6	1.0	-90	88	34	28	2520	-56	54
1	-5	1.3	-89	87	35	29	3162	-55	53
2	-4	1.6	-88	86	36	30	3981	-54	52
3	-3	2.0	-87	85	37	31	5012	-53	51
4	-2	2.5	-86	84	38	32	6310	-52	50
5	-1	3.2	-85	83	39	33	7943	-51	49
6	0	4.0	-84	82	40	34	10,000	-50	48
7	1	5.0	-83	81	41	35	12,589	-49	47
8	2	6.3	-82	80	42	36	15,849	-48	46
9	3	7.9	-81	79	43	37	19,953	-47	45
10	4	10.0	-80	78	44	38	25,199	-46	44
11	5	12.6	-79	77	45	39	31,623	-45	43
12	6	15.8	-78	76	46	40	39,810	-44	42
13	7	20.0	-77	75	47	41	50,119	-43	41
14	8	25.2	-76	74	48	42	63,096	-42	40
15	9	31.6	-75	73	49	43	79,433	-41	39
16	10	39.8	-74	72	50	44	100,000	-40	38
17	11	50.1	-73	71	51	45	125,890	-39	37
18	12	63.1	-72	70	52	46	158,490	-38	36
19	13	79.4	-71	69	53	47	199,530	-37	35
20	14	100	-70	68	54	48	251,990	-36	34
21	15	126	-69	67	55	49	316,230	-35	33
22	16	158	-68	66	56	50	398,100	-34	32
23	17	200	-67	65	57	51	501,190	-33	31
24	18	252	-66	64	58	52	630,960	-32	30
25	19	316	-65	63	59	53	794,330	-31	29
26	20	398	-64	62	60	54	1,000,000	-30	28
27	21	501	-63	61	61	55	1,258,900	-29	27
28	22	631	-62	60	62	56	1,584,900	-28	26
29	23	794	-61	59	63	57	1,995,300	-27	25
30	24	1000	-60	58	64	58	2,519,900	-26	24
31	25	1259	-59	57	65	59	3,162,300	-25	23
32	26	1585	-58	56	66	60	3,981,000	-24	22
33	27	1995	-57	55					

NOTES: 1. The above shows the relationship among five commonly used units for expressing noise in a voice band channel. In columns 1 through 4, the units represent weighted noise at a point of zero relative level. In column 5, the S represents a tone at zero relative level and the N represent unweighted noise in a 3-kHz voice channel. Therefore, S/N is the dB ratio of test tone to noise. This column may also be interpreted as negative dBm noise readings, flat weighted.

2. The above is based on the following commonly used correlation formulas which include some slight roundoffs for convenience. Correlations for columns 2, 3, and 4 are valid for all types of noise. All other correlations are valid for white noise but not necessarily for other types.
$dBrncO = 10 \log_{10} pWpO = dBaO + 6 = dBmOp + 90 = 88 - S/N$

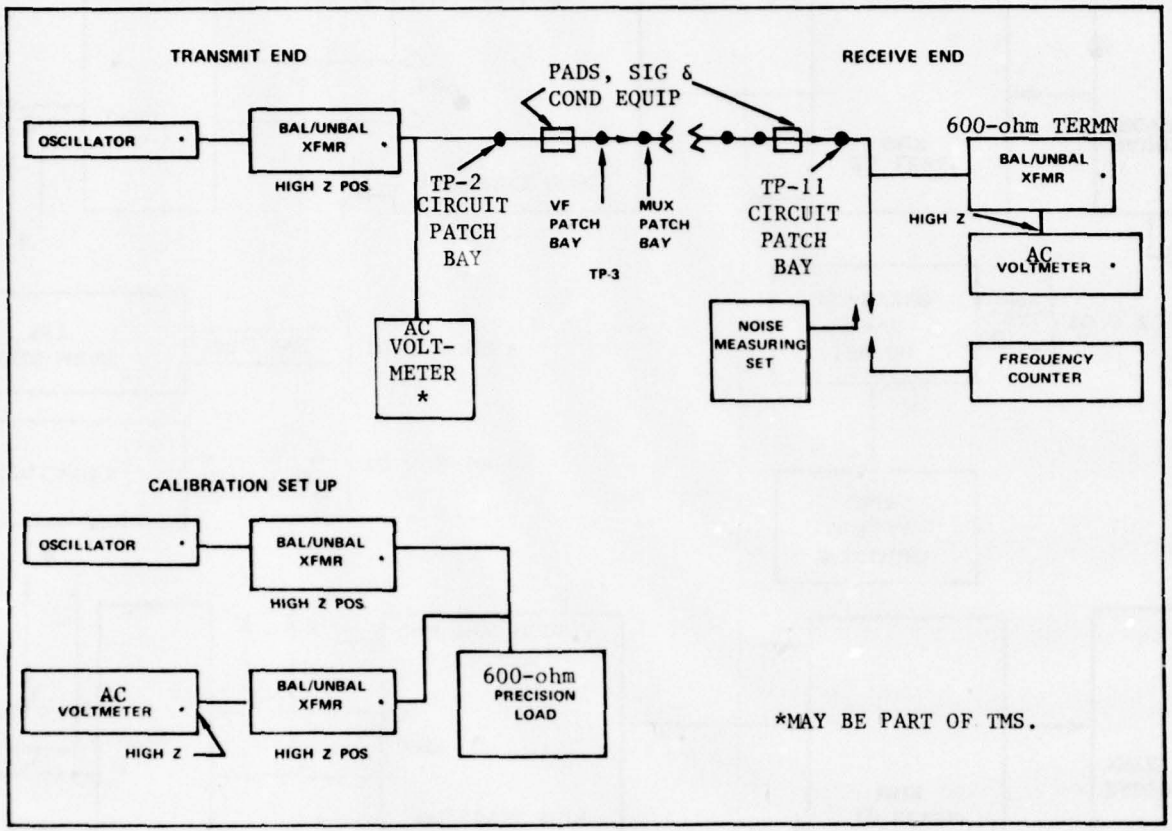


Figure 75-1. Circuit noise and single tone interference (calibration).

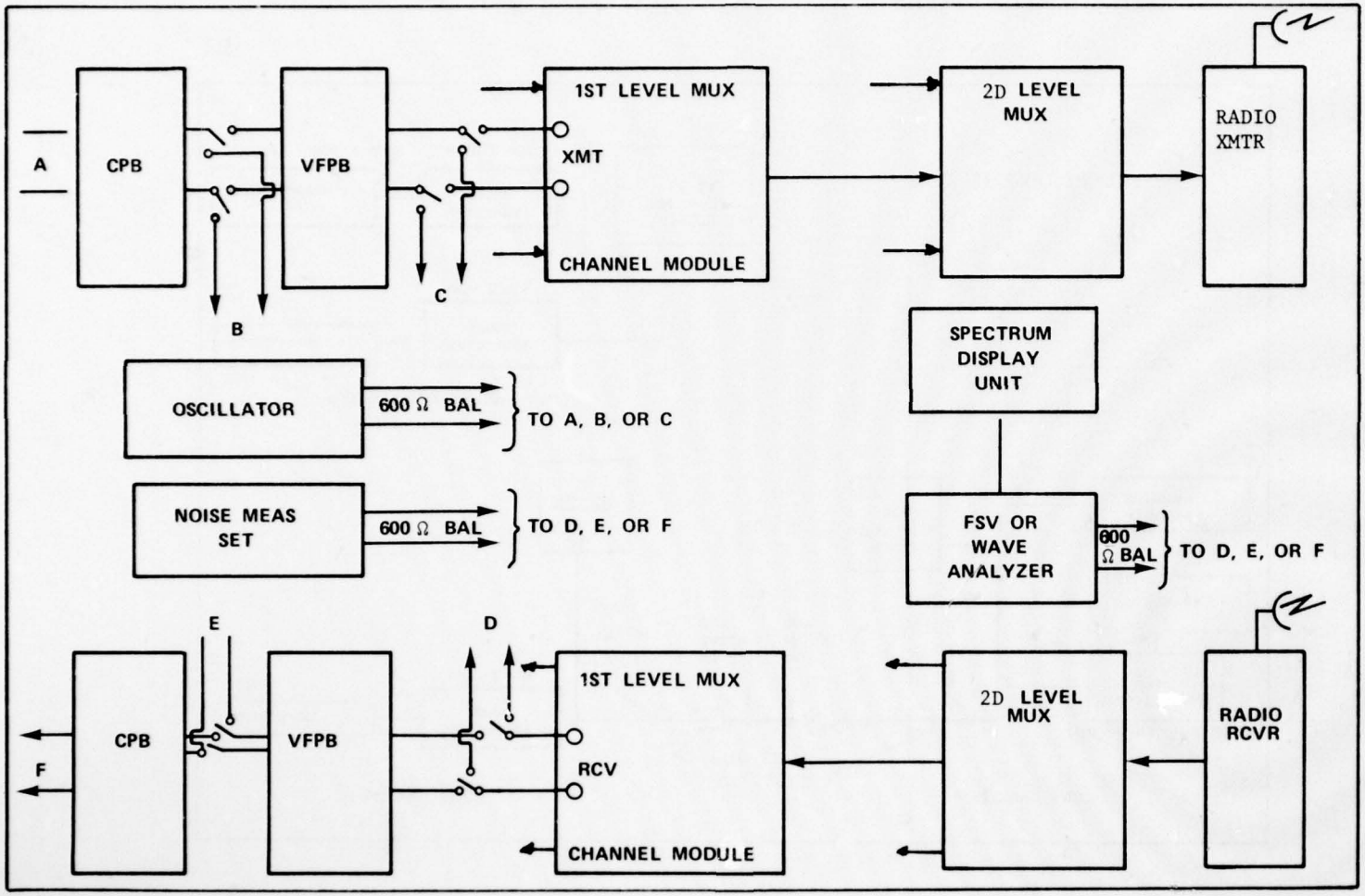


Figure 75-2. Circuit noise and single tone interference test setup.

CHAPTER 76

E&M SIGNALING (DT-273)

76-1. GENERAL.

a. The purpose of this test is to measure the performance characteristics and pulse transfer of the receive and transmit (E&M) signaling circuits associated with the digital multiplex equipment.

b. This test may be performed at the VFPB, at the channel SG test point, or at any other test point where the E&M leads are accessible.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

76-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) Each voice frequency channel shall provide E&M signaling interface. A one (1) shall be transmitted for an off-hook condition and a zero (0) for an on-hook condition. The multiplex terminal shall interpret the receipt of a one (1) and a zero (0) as an off-hook and on-hook condition respectively. The input/output interface conditions for signaling shall be as follows:

CONDITION	E-LEAD	M-LEAD
On-hook	Open	Ground
Off-hook	Ground	Battery (-48 VDC ±5 volts)

(2) The signaling circuit shall not respond to transients on the M-lead of a magnitude less than 5 VPP. Dial pulsing shall be accomplished after seizure by transferring the A-lead from battery to ground and back to battery for each pulse.

(3) The signaling equipment shall transmit dial pulses within the range of 8 to 12 pulses per second (pps) with a percent break (percentage of the time on ground for the M-lead) of 42 to 72 percent at 17 to 19 pps, the percent break shall be 60 to 70. The variation in percent break appearing on the E-lead for both conditions (8 to 12) and (17 to 19) with the multiplex properly looped shall be within ±5 percent of the A-lead pulsing speed and percentage break range.

b. The AN/FRC-162 and VICOM 4000-2 system shall operate as follows:

(1) 10 pps (nominal) with 50-percent break (transmit).

(2) 45- to 55-percent break (receive).

c. The signaling equipment shall operate as specified in the standard engineering plan or contract specifications.

76-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Signaling test set.

c. Noise measuring set.

d. Oscillator.

e. Oscilloscope.

76-4. TEST PROCEDURES.

a. If the system is in traffic and carrying E&M signaling circuits, notify the telephone exchange switchman to busy-out those channels that are to be tested.

b. On the multiplex/demultiplex, check the strapping for proper voice frequency level and two- or four-wire operation as specified in the equipment technical manual.

c. For the AN/FRC-162 and VICOM 4000-2 system, proceed as follows:

(1) Throw all switches down on the TSEC/CY-104 transmit and receive terminal common equipment. Verify that all alarms are extinguished on the 7070 panel.

(2) Operate the channel make-busy switches to the up position for those channels to be tested, especially if the channels are connected to external trunk circuits. This will busy-out trunks to be tested and prevent false trunk seizure through the telephone exchange.

(3) If the test is being performed from one of the station patch bays, connect the test equipment as shown in figure 76-1 and allow approximately 30 minutes for warmup and stabilization. If a local loopback is required, patch the bipolar or NRZ output to the bipolar or NRZ input at the 1st and 2d level multiplexers as required.

(4) At the transmit end, inject a 0-dBm0, 1020-Hz test tone into the channel under test. The test tone should be -10 dBm0 for systems that are carrying operational traffic.

(5) At the receive end, measure and record the tone level on figure 76-2 (USACC Form 662-R). Terminate the voice frequency channel under test into the 600-ohm balanced input of the noise measuring set.

(6) At both ends of the circuit:

(a) Connect the office -48 volt battery to he 48 volt/ground jack of the test set using a suitable patch cord.

(b) Patch the signal link jack of the test set to the E&M leads of the channel under test or to the signal jack on the channel module (fig. 76-3).

(c) Operate the E turnkey of the test set to open/ground (vertical).

(d) Operate the M turnkey to battery/ground (vertical).

(e) Operate the toward line key of the test set to off-hook (transmit end).

NOTE: If performing a local channel test, set the on-hook/off-hook switch of the BITE to off-hook. The off-hook light on the BITE should light in both cases.

(f) Set the toward drop key to normal.

(g) Operate the toggle switch to continuous pulse.

(h) Depress the press-to-measure-speed pushbutton; operate the loop/leak key to loop; and adjust the preset speed control until the meter reads 10 pps. Lock the control in position.

(i) With all the control keys in the middle position and the toggle switch on dial pulse, adjust the set-full-scale control until the meter reads full scale (0-percent break).

(j) Operate the loop/leak key to loop and the toggle switch below the dial to continuous pulse. Adjust the preset-loop-percent-break control until the meter reads 50-percent break. Lock the control.

(7) At the receive end, set the test set to receive pulses on the E-lead.

(8) At the transmit end, operate the outgoing keys to send loop and pulse.

(9) At the receive end, operate the incoming key to measure and depress the press-to-measure-speed switch to measure the speed of the received dial pulses. The meter should read 10±0.5 pps on the pulse-per-second scale. Record the readings on the data sheet.

(10) At the receive end, release the press-to-measure-speed switch to measure the precent break of the received pulses. The meter should read from 45 to 55 percent on the percent break scale. Record the readings on the data sheet.

NOTE: The channel unit E-lead is on the tip and the M-lead on the ring. Observe the correct E- to M-lead input/output when making patches at the patch bay or at the equipment. Different test equipment may use different nomenclatures or test connections; therefore, refer to the operating instructions of the test set being used.

d. For the TD-1192 (AN/FCC-98) proceed as follows:

(1) Connect the multiplex in a back-to-back loop by patching the PCM output to the PCM input as shown in figure 76-1, if a loop test is to be performed.

(2) Set up the test set to measure the pulse speed and percent break as outlined in paragraph 76-4b, above.

(3) On the BITE, turn the digital function rotary switch to any position except power off.

(4) Operate the make-busy switches to busy-out the trunk if the system is in traffic.

(5) Verify that the terminal is configured and strapped for E&M operation.

(6) On the BITE, set the on-hook/off-hook toggle switch to off-hook (fig. 76-3).

(7) Using a suitable patch cord, first insert the patch cord into the signal jack on the voice frequency module, and then insert the other end into the signal jack on the BITE.

(8) Depress the carrier group alarm defeat pushbutton on the power-alarm, and observe that the off-hook lamp on the BITE lights.

(9) Remove the patch cord from the signal jack on the BITE and then remove the other end from the signal jack on the voice frequency module.

(10) Connect the test set to the signal jack of the voice frequency module as shown in figure 76-3. Observe the tip-ring polarity.

(11) Connect the test set to the -48 VDC station battery.

(12) Set the test set to read the number of dial pulses and percent break as outlined in paragraph 76-4c, above, except:

(a) Set the transmit pulses for 10 pps.

(b) Set the percent break between 42 and 72 percent.

(13) At the receive end, measure and record the number of pulses per second and the percentage of break on the data sheet. Also record the variations on the data sheet.

(14) Set the test set to send 17 to 19 pps and at a percent break between 60 to 70 percent.

(15) At the receive end, measure the pps and percentage of break on the data sheet. Also record the deviation.

(16) With the M-lead off-hook and all test equipment removed, momentarily place a 5 VPP DC voltage on the M-lead. Observe that the signaling equipment does not respond to the transient voltage.

e. For the TSEC/HY-12, proceed as follows:

(1) Set the switches on the test set as follows:

(a) Meter circuit to percent break through the meter relay.

(b) Function (rotary switch) to calibrate meter.

(c) Send pps to 10.

(d) Receive to fully clockwise.

(e) Send to E&M, line, E = G&O, M = B&G.

(f) Function lever switch to send dial.

(2) Adjust the meter calibration control for a meter reading of 0-percent break.

(3) Set the rotary function switch to adjust percent break. Place the function lever in the send oscillator position and set the adjust percent break control for a meter reading of 40-percent break. Return the function lever to the send dial position.

(4) Set the rotary function switch to the send and receive position.

(5) Connect the ground wire between the ground terminal of the test set and the HY-12 chassis of both terminals.

(6) Connect the E&M signaling line jack as follows:

(a) Tip to terminal B, channel 1, E-lead.

(b) Ring to terminal A, channel 1, M-lead.

(7) Place the function lever switch in the send oscillator position and

check for a meter reading of approximately 40-percent break. Return the switch to the send dial position.

f. Reverse the direction of transmission and testing and repeat the applicable procedures for all remaining voice frequency channels.

76-5. DATA RECORDING AND ANALYSIS.

a. Record all test results on the data sheet and review the results for compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the channel, circuit, or equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

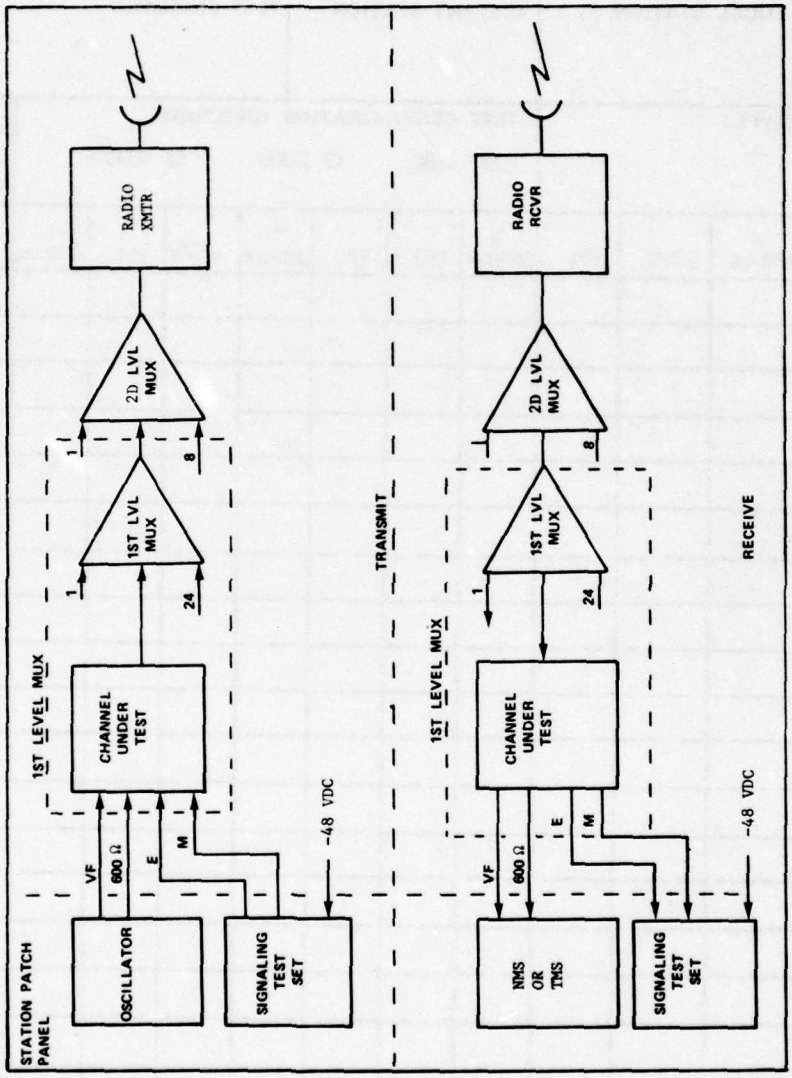


Figure 76-1. Voice channel E&M signaling test setup.

VF CHANNEL SIGNALING (CCR 702-1-3) DATA SHEET				PAGE OF PAGES DATE (Day, Mo, Year)								
LINK NO	LOCAL STATION			DISTANT STATION				TEST ENGINEER				
EQUIP TESTED (TYPE)				TEST CONFIGURATION (DESCRIBE) ☐ LINK ☐ LOOP ☐ OTHER								TRANSIENT ☐ PASSED ☐ FAILED
CHAN NO.	PPS	% BREAK	DEVN	PPS	% BREAK	DEVN	PPS	% BREAK	DEVN	PPS	% BREAK	DEVN

USACC FORM 662-R Figure 76-2. VF channel signaling data sheet.
1 MAY 79

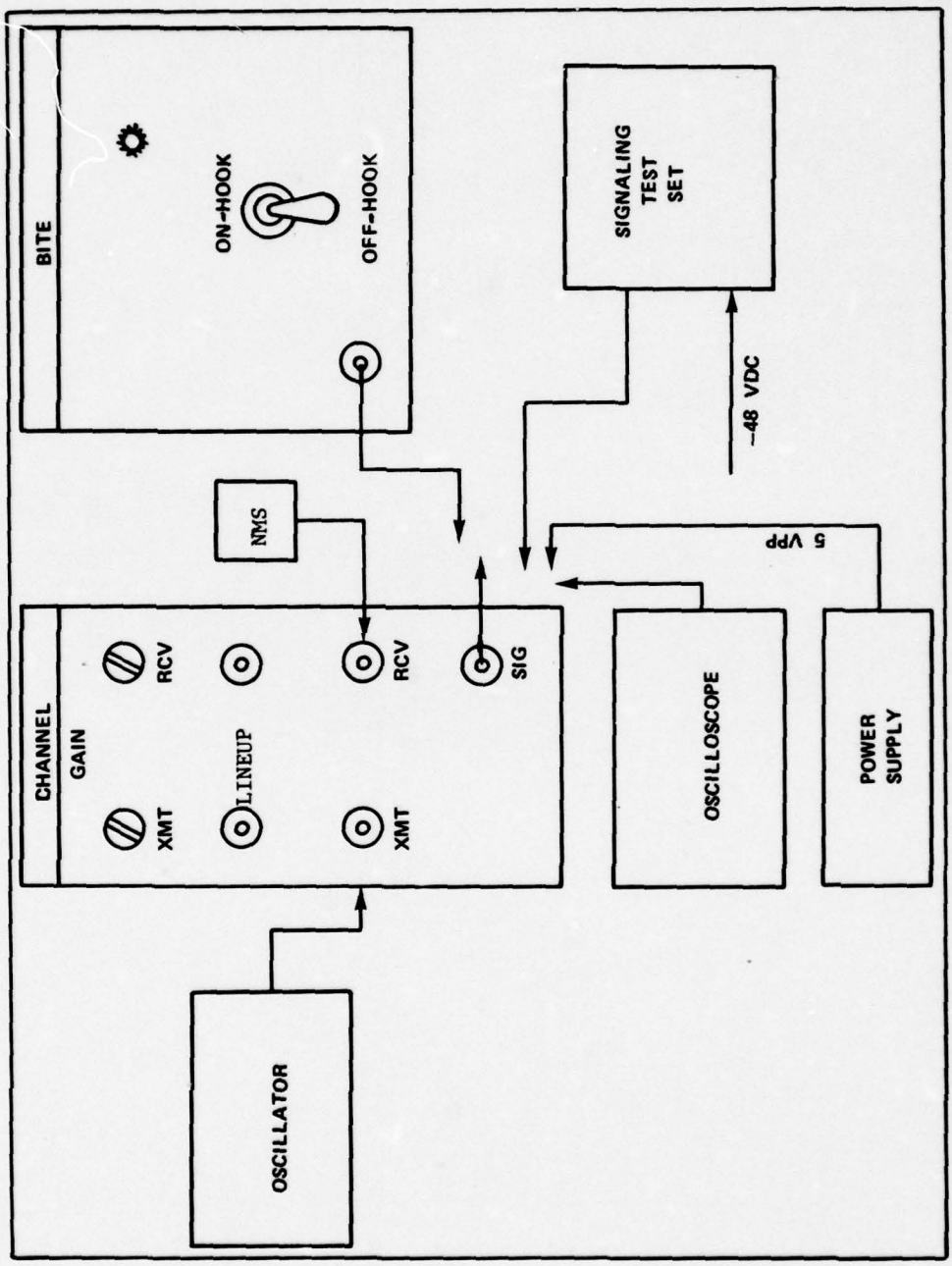


Figure 76-3. Voice channel loopback and on-line test setup.

CHAPTER 77

MULTIPLEX LOOPBACK AND LOOPBACK ALARM (DT-274)

77-1. GENERAL.

a. The purpose of this test is to demonstrate and verify the built-in loopback capabilities of the multiplex.

b. This test is applicable to the TD-1192 (AN/FCC-98) 1st level multiplex and the TD-1193 2d level multiplex.

c. This test may be performed on contractor EF&I systems to verify that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

d. Normally, this would be a design verification test and would not be performed during routine onsite testing.

77-2. SPECIFICATIONS.

a. The data and timing from the TD-1192 (AN/FCC-98) shall be looped back internally to the demultiplexer by means of a switch accessible from the front of the multiplex terminal. When the multiplex terminal is looped back, a white light on the front panel shall illuminate; a bit stream of all 1's in every position including framing bit positions shall be transmitted to the receive (far) end multiplex terminal for the duration of the loopback mode; and a remote alarm closure shall be provided. The all 1's condition shall be detected by the receive end multiplex terminal and shall cause a white light on the front panel of the receive multiplex terminal to illuminate and a remote alarm closure to activitate. An external test tone level command applied to a connector on the multiplexer terminal shall also initiate a loopback function. (CCC-74047)

b. The TD-1193 MBS data and timing from the TDM output shall be looped back internally to the TDM input by means of a switch accessible from the front of the TDM. When the TDM is looped back, a white light on the front panel shall illuminate and a remote alarm closure shall be provided. An external command applied to a connector on the TDM shall also initiate the loopback function. (CCC-74048)

c. For the AN/FRC-162 ard VICOM 4000-2 system, refer to DT-303 for alarm operation of this equipment.

d. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

77-3. TEST EQUIPMENT REQUIRED.

a. Ohmmeter.

b. Programmable calculator.

c. Calculator interface bus.

d. Analyzer.

e. Oscilloscope.

f. DC power supply.

77-4. TEST PROCEDURES.

a. General. The information contained in paragraph 77-2 and the procedures outlined below are not directly applicable to the AN/FRC-162 and VICOM 4000-2 system. However, certain portions of the procedures may be performed on the AN/FRC-162 and VICOM 4000-2 system as directed. These procedures will be repeated for the reverse direction of transmission.

b. TD-1192 (AN/FCC-98).

(1) At the transmit and receive ends, connect the equipment as shown in figure 77-1 for automatic measurements or for manual verification.

(2) If the automatic method is used, program the calculator to:

(a) Command a multiplex loop at the TDM output through the test tone level external connector.

(b) Automatically sense the closure of the external back-to-back relay contacts at the back of the monitor and alarm subsystem.

(c) Issue bandwidth, synchronizing, trigger, and level commands to the analyzer or oscilloscope so that a series of 1's are detected as long as the loopback exists.

(d) Print out each completed step and provide a local alarm for any step that could not be completed.

(3) At the transmit end, observe that a white loopback and loopback alarm light activates on the monitor and alarm panel. Also that a series of 1's are being transmitted to the receive end as observed on the analyzer or oscilloscope.

(4) Note that the external alarm contacts activate.

(5) At the receive end, note that a series of 1's are being received on the analyzer or oscilloscope and that the white loopback alarm (remote) light

is activated. Also note that the external alarm relay contacts energize and remain energized as long as the receive end remains in a local loop configuration.

c. Manual Method.

(1) At the transmit (near) end:

(a) Connect an analyzer or oscilloscope to the TDM output as shown in figure 77-1. Connect an ohmmeter to the external loop alarm contacts.

(b) On the monitor and alarm panel, place the TDM baseband switch to the back-to-back position and observe that the loopback light (white) and the loopback alarm light (white) illuminate.

(c) Adjust the analyzer to observe that a repetitive pattern of all 1's are being transmitted to the receive end and that the ohmmeter reflects a relay contact closure. Record the test results on figure 77-2 (USACC Form 663-R).

(2) At the receive end:

(a) Connect the oscilloscope or analyzer to the multiplex TDM input and note that 1's are being received in all positions of the bit stream including the framing positions.

(b) Note that a remote alarm light (white) activates and the ohmmeter indicates a contact closure. Also note that the loopback alarm light activates.

(c) Record the results on the data sheet.

(3) At the transmit end, place the loop switch in the normal operating position and at both ends ensure that all alarms have extinguished. Connect an extermal test tone level voltage ±6 VDC to the test tone level input connector of the multiplexer and note that a loopback alarm light activates.

(4) Repeat subparagraphs (1) and (2), above, for the transmit and receive ends.

d. TD-1193.

(1) Connect the test equipment as shown in figure 77-3.

(2) At the transmit end, place the loopback switch on the protection and control module to the loopback position. Observe that a white light on the monitor and alarm panel illuminates, and the ohmmeter connected to the external relay contacts of the protection and control module indicates contact closure.

(3) At the receive end, observe that the loss of MBS input and frame lights (red) activate. Measure each external alarm contact closure at the protection and control module rear panel. Record the results on the data sheet.

NOTE: Other alarm conditions may exist when the loopback switch is activated at the transmit end; however, it is only necessary to measure the external alarms in subparagraph (3), above, for this test. The remaining alarms and contact closures will be demonstrated in DT-302 and DT-303.

(4) At the transmit end, place the loopback switch in the normal operating position. At both ends of the circuit, observe that all alarm conditions have extinguished.

(5) At the transmit end, inject a test tone level voltage on the external loopback control terminals on the rear of the protection and control modules.

(6) Repeat subparagraphs (2) and (3), above, except do not activate the manual loopback switch.

(7) Record all results on the data sheet.

77-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the test results for accuracy and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal operating configuration.

c. If the equipment fails to meet specified performance requirements notify the responsible activity of required corrective actions.

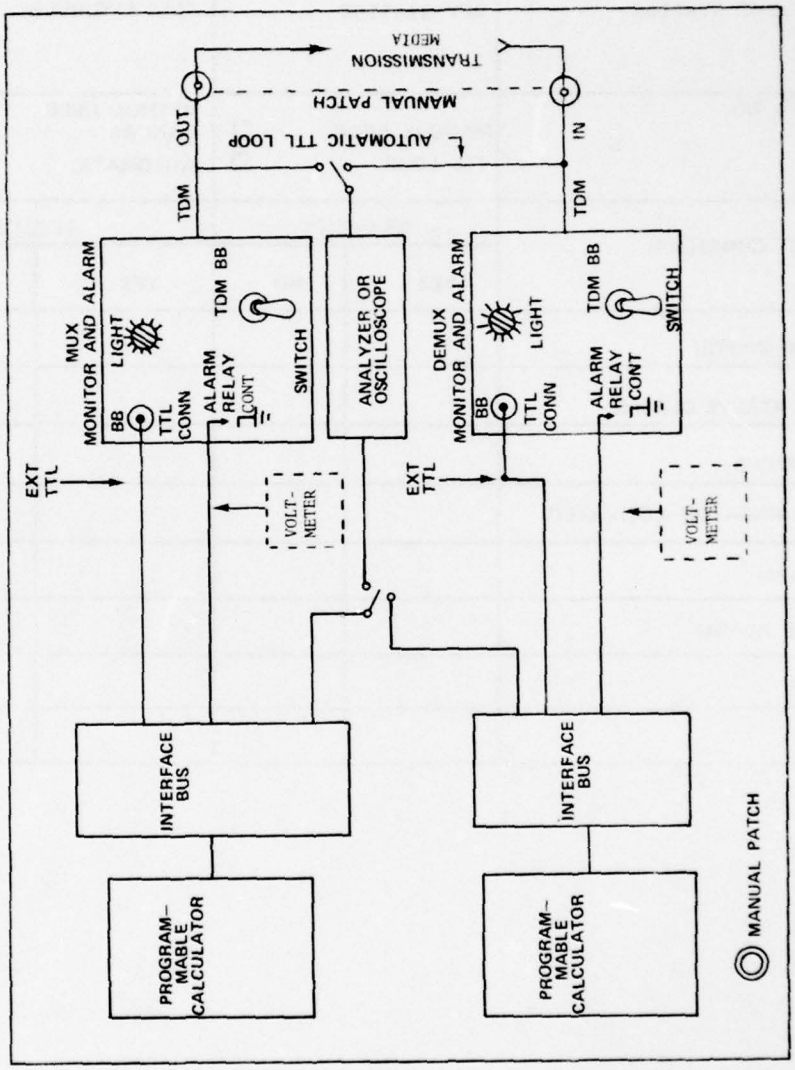


Figure 77-1. Multiplex (TD-1192) loopback and loopback alarm test setup.

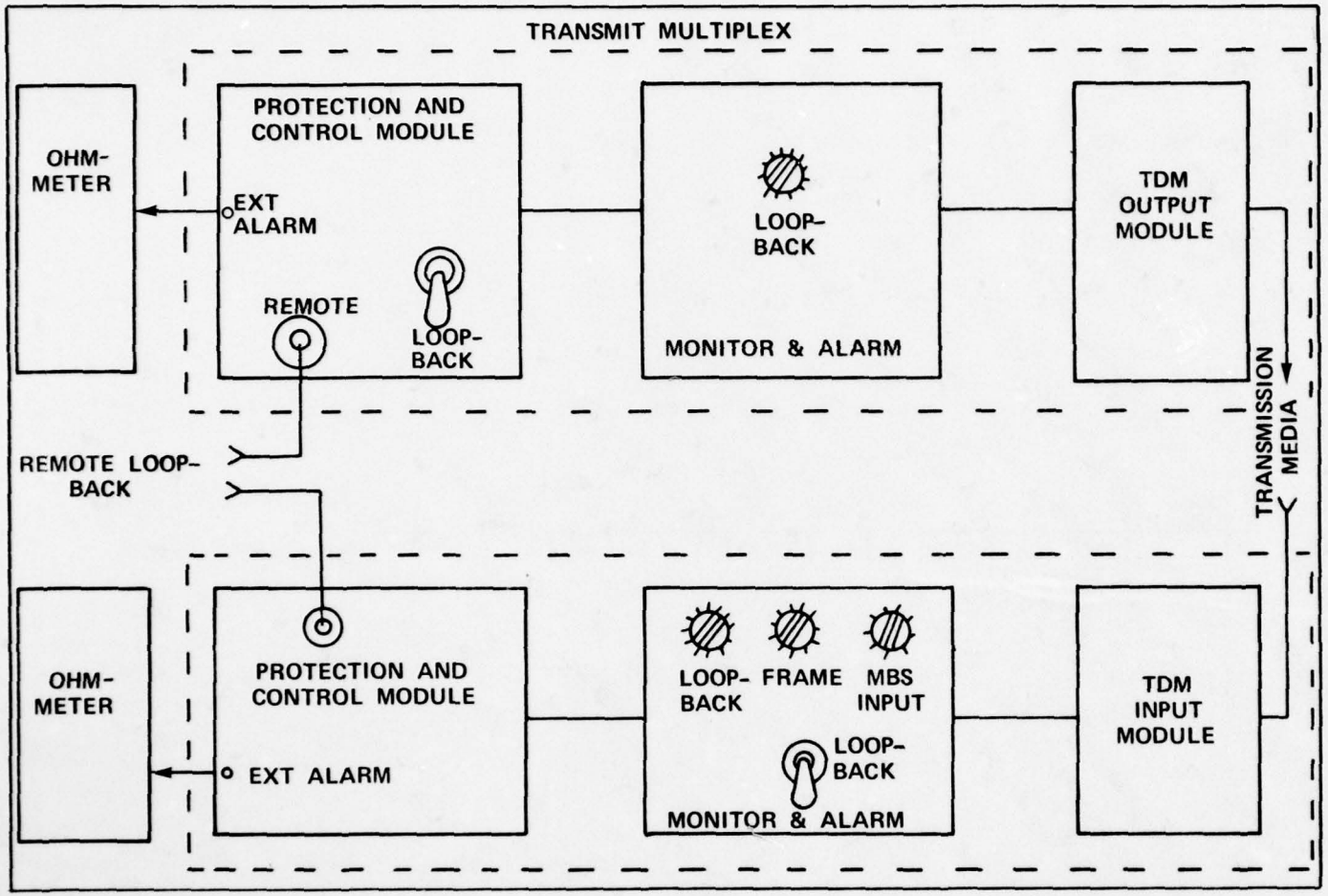
MULTIPLEX LOOP AND CARRIER GROUP ALARM (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	XMT STATION	RCV STATION	TEST ENGINEER
EQUIP TESTED & NO.		MANUAL LOOP ☐ TTL LOOP ☐	METHOD USED MANUAL ☐ AUTOMATIC ☐

TEST CONDITION	TRANSMIT		RECEIVE	
	YES	NO	YES	NO
LOOP LIGHT ON (WHITE)				
EXT RELAY CONTACTS CLOSED				
ALL 1's XMTD/RCVD				
MBS & CLOCK INDICATOR ACTIVATED				
MBS INPUT ALARM				
LOSS OF FRAME ALARM				
TTL AUTOMATIC				
TTL MANUAL				

COMMENTS

USACC FORM 663-R
1 MAY 79

Figure 77-2. Multiplex loop and carrier group alarm data sheet.



77-7

CCP 702-11

Figure 77-3. Multiplex (TD-1193) loopback and loopback alarm test setup.

CHAPTER 78

CARRIER GROUP ALARM (DT-275)

78-1. GENERAL.

a. The purpose of this test is to determine the performance characteristics of the carrier group alarm of the 1st level multiplex.

b. This test is applicable to the TD-1192 (AN/FCC-98) multiplexer and certain portions are also applicable to the 1st level multiplex equipment used in the AN/FRC-162 and VICOM 4000-2 system.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

78-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98).

(1) The multiplex termainal shall be provided with a carrier group alarm which is activated upon occurrence of any of the following alarm conditions.

(a) Power supply monitor and alarm.

(b) Loss of output alarm.

(c) Loss of input alarm.

(d) Loopback and loopback alarm.

(e) Loss of frame alarm continually present for 300±100 msec.

(2) In addition, the near end multiplexer terminal shall transmit an alarm pattern to the far end multiplex terminal for the following alarm conditions.

(a) Loss of frame alarm.

(b) Loss of output alarm.

(c) Loss of input alarm.

(3) The alarm pattern generated in the transmit end multiplex terminal shall force the second bit of every channel word (8 bits) to zero, and this pattern shall be transmitted for the duration of the alarm conditions in subparagraph (2), above. The receive end multiplex terminal shall detect the alarm pattern received in the incoming digital bit stream and initiate a

carrier group alarm until the pattern ceases. A white light shall illuminate on the front panel of each multiplex terminal indicating that the carrier group alarm is activated.

(4) A remote alarm closure shall be provided.

(5) The multiplex shall place an alarm on the output data of every channel card for any occurrence of the carrier group alarm. This data alarm pattern shall consist of forcing all output bits of each data channel card to 1's and this pattern shall be sent for the duration of the carrier group alarm.

b. The criteria for the AN/FRC-162 and VICOM 4000-2 system shall be basically the same as the TD-1192.

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

78-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. BER test set.

c. Ohmmeter.

78-4. TEST PROCEDURES.

a. Loss of Input Power.

(1) Connect the test equipment as shown in figure 78-1 and allow approximately 30 minutes for warmup and stabilization.

(2) At the transmit end, simulate a primary power failure to the multiplex by removing the -48 VDC fuse.

(3) Connect the voltohmmeter to the external power and alarm contacts on the monitor and alarm panel. Note that the ohmmeter reads a contact closure. Record the results on figure 3-7 (DD Form 2091).

(4) Restore power to the multiplex and observe that the power on lamp illuminates and the carrier group alarm lamp extinguishes.

b. Loss of Output.

(1) Connect the multiplex for NRZ operation and set the BER test set to provide data to the data equipped channels.

(2) Momentarily ground the MBS clock at the transmit end and observe the following:

(a) Output loss (RED) lamp illuminates.

(b) Local indicator illuminates.

(c) Carrier group alarm lamp illuminates.

(d) At the receive end, the remote and loss of input lamps illuminate.

(3) Temporarily ground the MBS data and observe that the alarm indicators react as stated in subparagraph (2), above.

(4) Remove the ground and observe that the alarm lamps extinguish.

(5) For each of the above, verify that the remote alarm terminal changes operational condition.

c. Loss of Input.

(1) Temporarily remove the MBS receive clock patch (fig. 78-1) and verify the following alarm conditions on the alarm panel of the receive unit.

(a) Carrier group alarm lamp illuminates.

(b) Remote indicator illuminates.

(2) Set the oscilloscope differential amplifier for plus and minus input at 1 volt per division. Set the time base trigger and scale for 1 usec per division.

(3) Connect the oscilloscope to the channel data out and verify a 11111111 pattern.

(4) Restore the MBS clock patch and temporarily remove the MBS receive data patch. Repeat subparagraph (3) above.

d. Loopback Alarm.

(1) At the transmit end, activate the loopback switch and at the receive end, observe that:

a. Carrier group alarm lamp illuminates.

b. Remote loopback lamp illuminates.

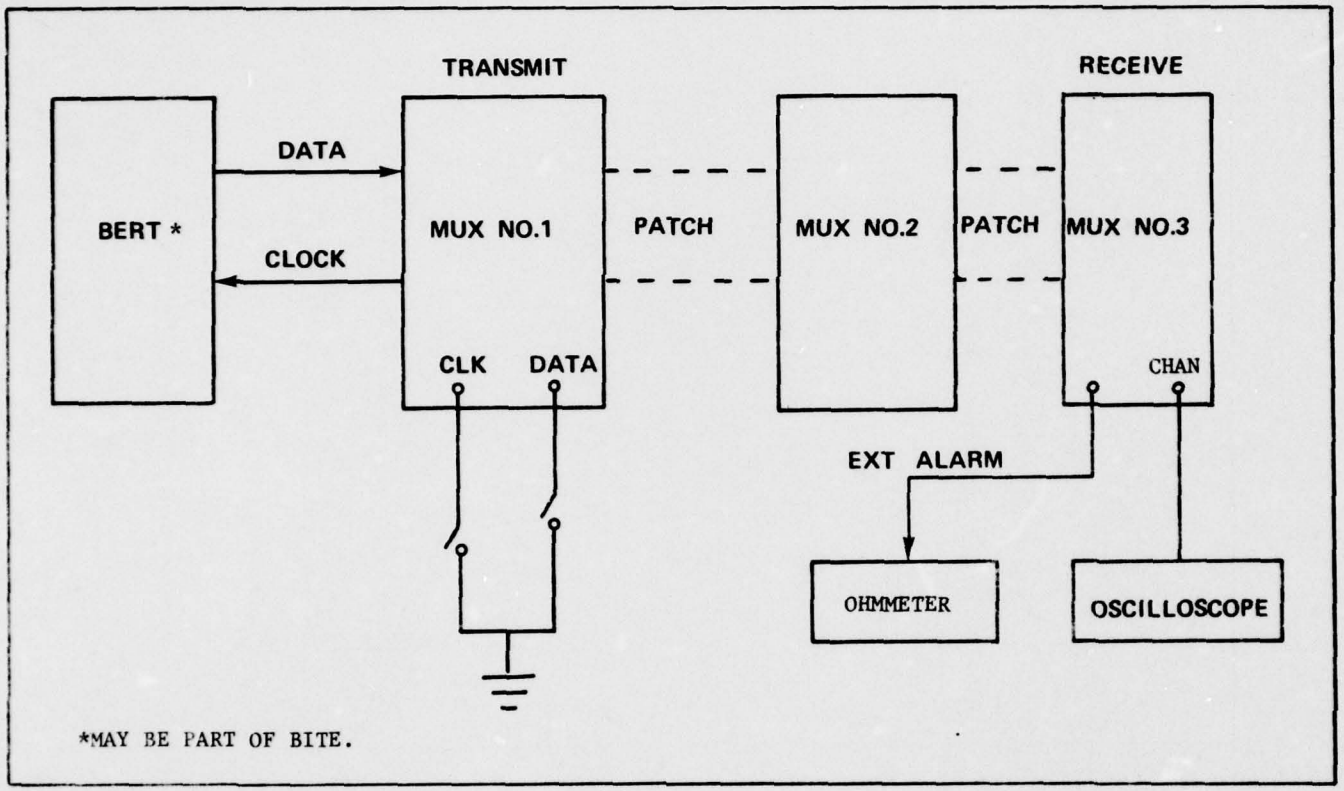
(2) Verify the contact change of the external carrier group alarm connector. At the receive end, verify that all 1's are being provided at the data channel output and that for each carrier group alarm all channels go to the busy state at the output.

78-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the data for completeness and compliance with specified requirements. Summarize the results on fiugre 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.



78-5

CCP 702-11

Figure 78-1. Carrier group alarm test setup.

CHAPTER 79

SIGNAL-TO-NOISE QUANTIZING (S/Nq) DISTORTION (DT-276)

79-1. GENERAL.

a. The purpose of this test is to measure the S/Nq distortion of the voice frequency channels of the digital multiplex/demultiplex equipment, either in a local loop or over the link.

b. The noise measured on an idle channel may not be the same as the noise on the channel when it is carrying traffic. Therefore, a measurement technique known as a notched noise measurement has been developed to measure noise in the loaded condition. In this technique, a test tone of approximately 1020 Hz (formerly 2804 Hz) is inserted at the transmit end. At the receive end, the tone is notched out by a narrow rejection filter. The remaining noise is passed through a weighting filter and measured in the normal manner. This technique should be used on digitally derived (PCM/TDM) channels.

c. Most of the noise results from the imperfect process whereby the analog voice is sampled at several finite amplitude levels and converted to a TDM format. Most systems divide the level to be sampled into unequal segments so that the lower level analog components have finer grain sampling than the higher level components. In this manner the SNR is relatively constant as a function of signal level. This test will provide a plot of SNR as a function of input signal level.

d. The noise should be measured with both 3-kHz flat and with C-message weighting. C-message weighting attenuates the 60-Hz noise components which may mask the noise measurements if powerline hum is a problem on the channel.

e. For total system noise performance, this test would be performed at the circuit patch bay; however, it may be performed at any instation voice frequency breakout point. If testing to determine equipment performance to design specifications, the test should be performed directly at the voice frequency input/output of the equipment.

f. This test may be performed on contractor EF&I systems to ensure that they meet specified performance. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

79-2. SPECIFICATIONS.

a. As a design objective, a sine wave signal with a frequency of 1000±25 Hz (preferably 1020 Hz) at the input to any audio channel of a long haul TDM/PCM reference voice bandwidth link shall produce, at the output of the same audio channel, a miminum test S/Nq ratio as shown in table 79-1. (MIL-STD-188-100)

Table 79-1. Signal-to-Noise Quantizing Ratio

INPUT SIGNAL in dBmO	INPUT SIGNAL in dBm at -16 TLP	MINIMUM TEST S/Nq Ratio in dB
0 to -25	-16 to -41	34
-26 to -30	-42 to -46	33
-31 to -40	-47 to -56	27
-41 to -45	-57 to -61	22

b. For the TD-1192 (AN/FCC-98), the total S/Nq of a sine wave signal at any frequency between 300 and 3400 Hz shall exceed the following minimum values (C-message weighted). (CCC-74047)

INPUT SIGNAL (dBmO)	S/Nq RATIO (dB)
From 3 down to -30	33
From -30 down to -40	27
From -40 down to -45	22

c. An AN/FRC-162 and VICOM 4000-2 system sine wave over the frequency range of 300 to 3400 Hz shall provide the following minimum S/Nq (C-message weighting).

INPUT SIGNAL (dBmO)	S/Nq RATIO (dB)
0 to -30	33
-40	27
-45	22

d. The multiplex/demultiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

79-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Noise measuring set.

c. Voltmeter.

d. Balanced/unbalanced transformer.

e. Slot filter, 1020 Hz.

f. Frequency counter.

g. Slot noise measuring set.

79-4. TEST PROCEDURES.

a. General. Complete the top portion of figure 79-1 (USACC Form 637-R), recording the equipment test tone power level (TLP) in dBm, the channel number under test, and other applicable information. For nonoperational systems, repeat the applicable procedure for each channel. On operational systems the test will be performed on only a sampling basis of the 24 channels per digroup. The random sampling should be a minimum of 6 channels for a 24-channel digroup. Reverse the direction of transmission and repeat the applicable procedure.

b. Multiplex/Demultiplex Back-to-Back Testing (Nonoperational Systems).

(1) Terminate all voice frequency channels into 600 ohms, except the channel under test.

(2) For those channels that have been extended to a local telephone exchange for E&M signaling, notify the exchange personnel to busy-out all trunks and operate the channel make-busy switches of the multiplex equipment to place a busy signal on all channels.

c. AN/FRC-162 and VICOM 4000-2 System (TSEC/CY-104/FCC-97).

(1) Place all switches on the transmit and receive ends common equipment to the down position and verify that all alarm lights are extinguished. Disconnect all patch cords and test equipment from the terminal under test.

(2) Connect a patch cable between the bipolar output and input jacks of the terminal interface unit patch field as shown in figure 79-2.

(3) At the transmit end:

(a) Set the 7060 test panel selector switch to distortion and connect the voltmeter to the jack of the test panel. Allow approximately 30 minutes for warmup and stabilization.

(b) Connect the external oscillator to the 7060 test panel oscillator in jack as shown in figure 79-2.

(c) Set the A and B pad attenuator switches to out and the oscillator output for 0 dBm0.

(d) Adjust the oscillator frequency for a maximum dip as read on the voltmeter. The dip should occur at 1020 Hz due to the notched filter built into the terminal equipment.

NOTE: For the remaining procedures, do not readjust the oscillator 1020-Hz output frequency.

(e) Patch the transmit lineup jack of the 7060 test panel to the channel under test and the panel selector switch to channel transmit.

(4) At the receive end:

(a) Patch the receive lineup jack of the channel under test to the jack of the test panel.

(b) Set the channel type switches (two and four wire) of the test panel to the type channel and termination being tested.

(c) Set the bridge/terminal switch of the test panel to bridging and connect the noise measuring set to the jack of the test panel. Set the noise measuring set to 600 ohms (terminated) and the range switch as necessary to measure the 1020-Hz transmitted tone.

(d) Measure and record the received tone on figure 79-1 (USACC Form 637-R).

(5) At the transmit end, set the controls as follows:

(a) Test panel selector switch to distortion.

(b) Weighting filter to C-message or flat. If testing the equipment to specifications use C-message weighting.

(c) Function switch to balanced.

(d) Input switch to 600 ohms, terminated.

(e) Response to damped.

(f) Range switch, as required.

Measure and record the noise for the channel under test.

(6) At the transmit end, reduce the oscillator output (in turn) to -30, -40, and -45 dBm0. At the receive end, measure the RSL and noise for each of the levels. Record all measurements.

NOTE: An alternate test configuration is shown in figure 79-3. With this method, the 1020-Hz notched filter is built into the test equipment and is automatically energized when the function switch is placed in the C-message position.

d. TD-1192 (AN/FCC-98).

(1) Place all switches on the transmit and receive ends common equipment to the down position and verify that all alarm lights are extinguished. Disconnect all patch cords and test cables from the equipment to be tested.

(2) On the multiplex terminal, place the loopback switch in the loopback position or activate a loopback condition through the external connector at the rear of the terminal equipment. If desired, the loopback can also be made by manually patching the PCM/TDM output to the input.

(3) For testing with BITE:

(a) Connect the test equipment as shown in figure 79-4.

(b) Connect the 1020-Hz oscillator output of the BITE to the transmit lineup jack and place the BITE selector switch to channel transmit level. Place the A and B attenuator pads to the out position and verify that a 0 dBm0 ±0.1 dBm tone is present on the channel to be tested.

(c) Connect the receive lineup jack to the ACVM jack of the BITE and place the selector switch to channel level receive. If there is a question on the accuracy of the BITE voltmeter, an external voltmeter may be connected to the receive lineup jack. The voltmeter should be in the 600-ohm balanced position. Measure the received 1020-Hz test tone and record this level on the data sheet.

(d) At the receive end, place the BITE selector switch to distortion. Read and record the distortion on the data sheet.

(4) For testing with external test equipment:

(a) Connect the test equipment as shown in figure 79-5.

(b) Adjust the oscillator to 1020±5 Hz as read on the frequency counter and adjust the output for 0 dBm0. If the channel input has been strapped for -16 dBm input, the oscillator should be adjusted to -16 dBm.

(c) Connect the noise measuring set to the receive lineup jack. Measure and record the 1020-Hz test tone level with the slot filter out of the circuit and with the instrument in the 600-ohm terminated position.

(d) Switch the slot filter into the circuit and note that a minimum level is being read on the noise measuring set. If there is a question as to the minimum level, slightly adjust the 1020-Hz transmitted tone while observing that the meter goes to a minimum value as the transmitted tone passes through the center of the slot filter.

(e) Set up the noise measuring set as outlined in paragraph 79-4(5), above. Measure the noise using C-message weighting. Record the measured noise level on the data sheet.

(f) Change the noise measuring set to 3-kHz flat weighting. Measure and record the noise in dBm on the data sheet.

(g) Convert the dBm readings in the 3-kHz flat and C-message columns of the data sheet to dBm0.

(h) Calculate the S/Nq value. Record this value on the data sheet. Since the equipment S/Nq requirements are based on C-message weighting, this is the information that should be entered on the data sheet.

(i) Without changing the oscillator frequency, adjust the oscillator output to 3 dBm0. At the receive end, measure the loading tone level and the noise. Record the measurements on the data sheet.

(j) Repeat subparagraph (i), above, at loading levels of -10, -15, -20, -25, -29, -30, -35, -40, and -45 dBm0. Record the results on the data sheet.

e. End-to-End Testing. This part of the test applies to systems using the TD-1192 (AN/FCC-98), the AN/FRC-162 and VICOM 4000-2 system, or similar digital equipment providing voice frequency circuits.

(1) Connect the test equipment as shown in figure 79-6 and verify that all alarms have extinguished.

(2) Normally, the end-to-end tests are performed at the circuit patch bay; however, if directed perform them at the VFPB or at the transmit end and receive lineup jacks of the multiplex equipment as shown in figure 79-6.

(3) At the transmit end, adjust the oscillator output for 0 dBm0 at a frequency of 1020±5 Hz as read on the frequency counter. If testing an operational system, the test tone should be inserted at -10 dBm0.

NOTE: Verify that the channels are strapped for 0-dBm0 operation and, if strapped for -16 dBm0, adjust the oscillator output accordingly.

(4) At the receive end, measure and record the level of the test tone in dBm to ensure that subsequent noise level measurements are valid. If the channel levels are not within specifications, they should be adjusted before proceeding with the test.

(5) At the receive end, connect the slot noise test set to the receive end of the channel to be tested, at the circuit patch bay, or other test points as directed. If a slot noise test set is available, adjust it according to the equipment operating manual. Switch in the filter circuit of the slot noise test set and tune the filter to produce a minimum level of the test tone. If a slot noise test set is not available and a fixed 1020-Hz filter is used, slowly change the transmitted tone frequency while observing the noise measuring set for a minimum reading.

(6) At the receive end, place the slot noise test set or noise measuring set to the C-message weighting position. Record the results on the data sheet. Change the instrument to 3-kHz flat weighting. Record the results on the data sheet.

(7) Convert the dBm readings to dBm0 and calculate the S/Nq value. Enter this value on the data sheet. This value should be based on the C-message noise values if the data is to be compared to the specifications contained in paragraph 79-2, above.

NOTE: If there is a significant difference (approximately 2 dB) in the C-message and flat weighting measurements, the cause should be investigated. This can be accomplished with a wave analyzer or by performing the test at other test points in the system to isolate the noise emanating source.

(8) Record the RSL on the data sheet as taken from the receiver quieting curve plotted on figure 3-4 (DD Form 2094). If the RSL is being recorded, reduce the recorded RSL to a median value and record this value on the data sheet.

(9) At the transmit end, change the oscillator output level to 3 (TD-1192 only), -10, -15, -20, -25, -30, -35, -40, and -45 dBm0.

(10) At the receive end, alternately measure the level of received loading tone and the noise level with the tone notched out. Record the values on the data sheet.

(11) If the RSL is recorded, determine the median value as outlined in the recording test (DT-311) and enter this value on the data sheet. Otherwise, enter the RSL value based on the AGC versus receiver quieting curve plotted on figure 3-4 (DD Form 2094).

79-5. DATA RECORDING AND ANALYSIS.

a. If required, plot the S/Nq versus the RSL on figure 3-4 (DD Form 2094).

b. Review all test results for accuracy and compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

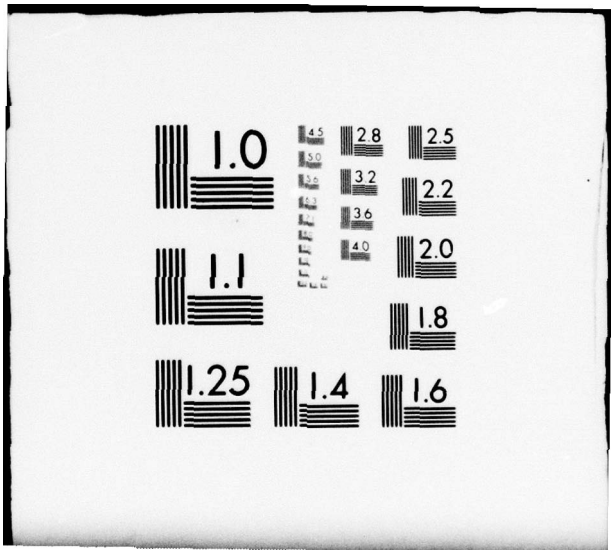
c. Remove all test equipment and restore the system to its normal configuration.

d. If the system fails to meet specified requirements, notify the responsible activity of required corrective actions.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

8 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0

SIGNAL-TO-NOISE QUANTIZING (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
TYPE EQUIPMENT			
1ST LEVEL MUX		2D LEVEL MUX	RADIO
XMT TP _____ TP dBm0 _____		RCV TP _____ TP dBm0 _____	LINK ☐ BACK-TO-BACK ☐

CHAN	1ST LVL MUX	2D LVL MUX	LOADING TONE		3-kHz FLAT NOISE			C-MSG NOISE (NOTCHED)			MEDIAN RSL
			dBm	dBm0	dBm	dBm0	S/Nq	dBm	dBm0	S/Nq	dBm

COMMENTS

USACC FORM 637-R
1 MAY 79

Figure 79-1. Signal-to-noise quantizing data sheet.

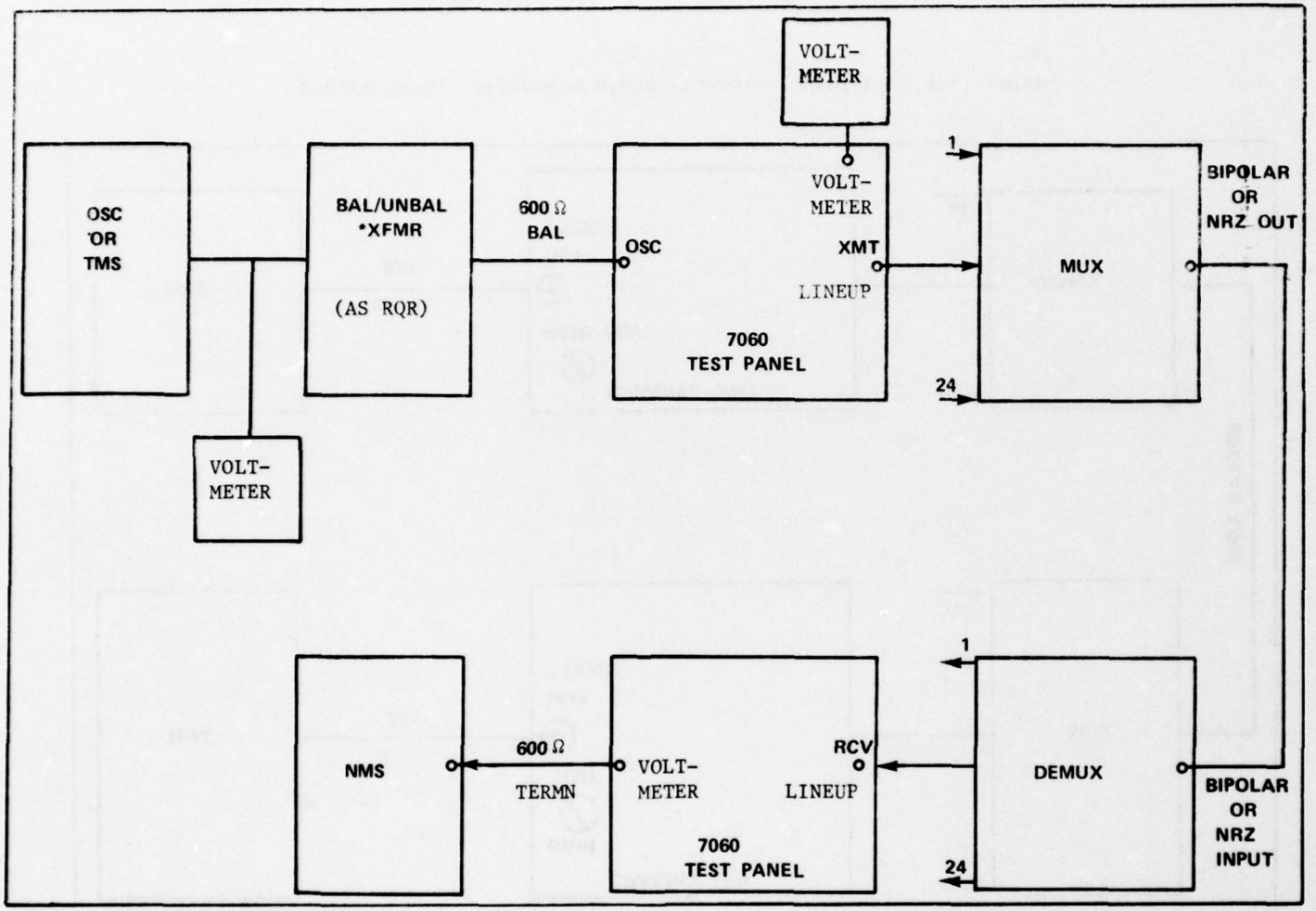


Figure 79-2. Signal-to-noise quantizing (AN/FRC-162 and VICOM 4000-2 back-to-back) test setup.

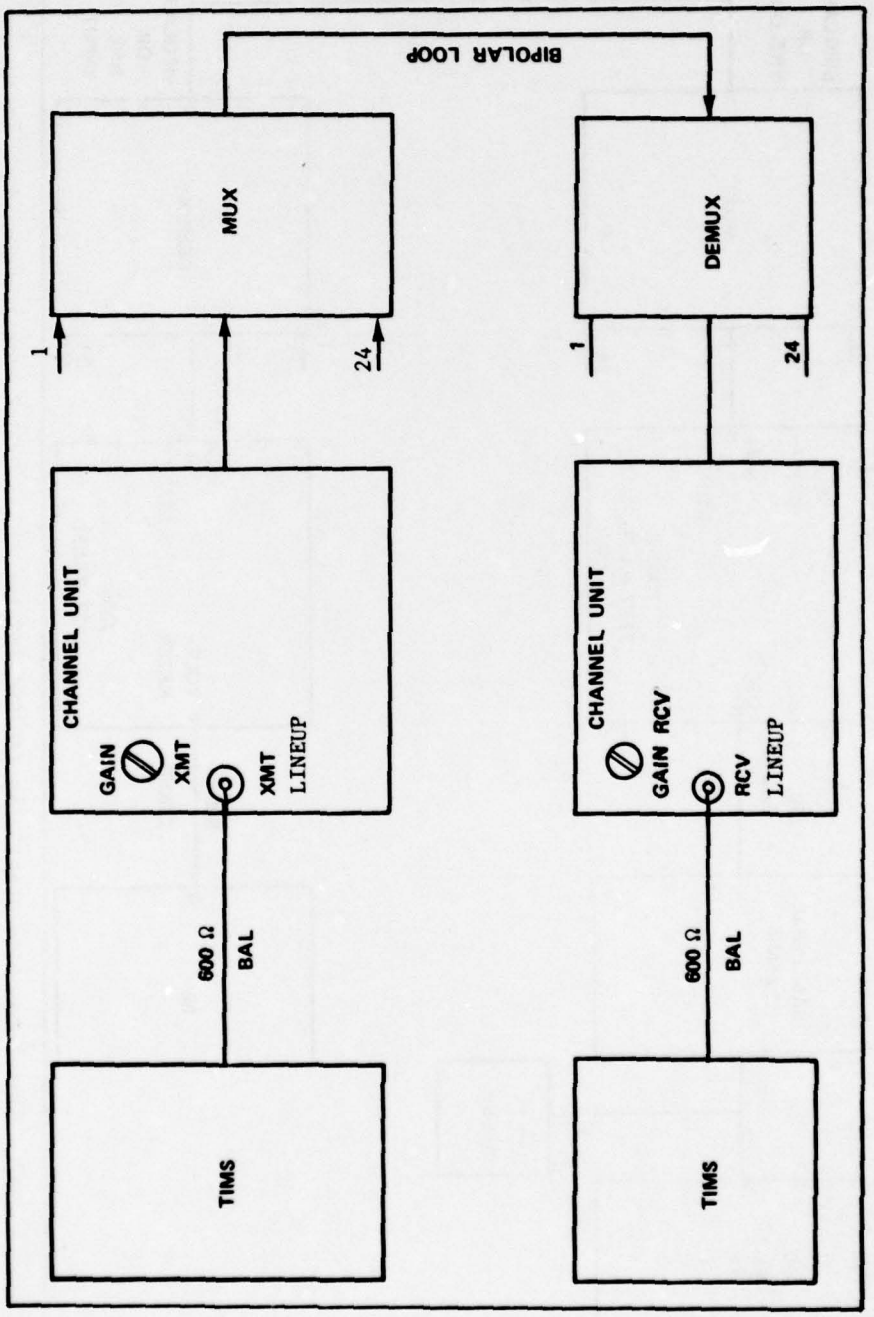


Figure 79-3. Alternate signal-to-noise quantizing test setup.

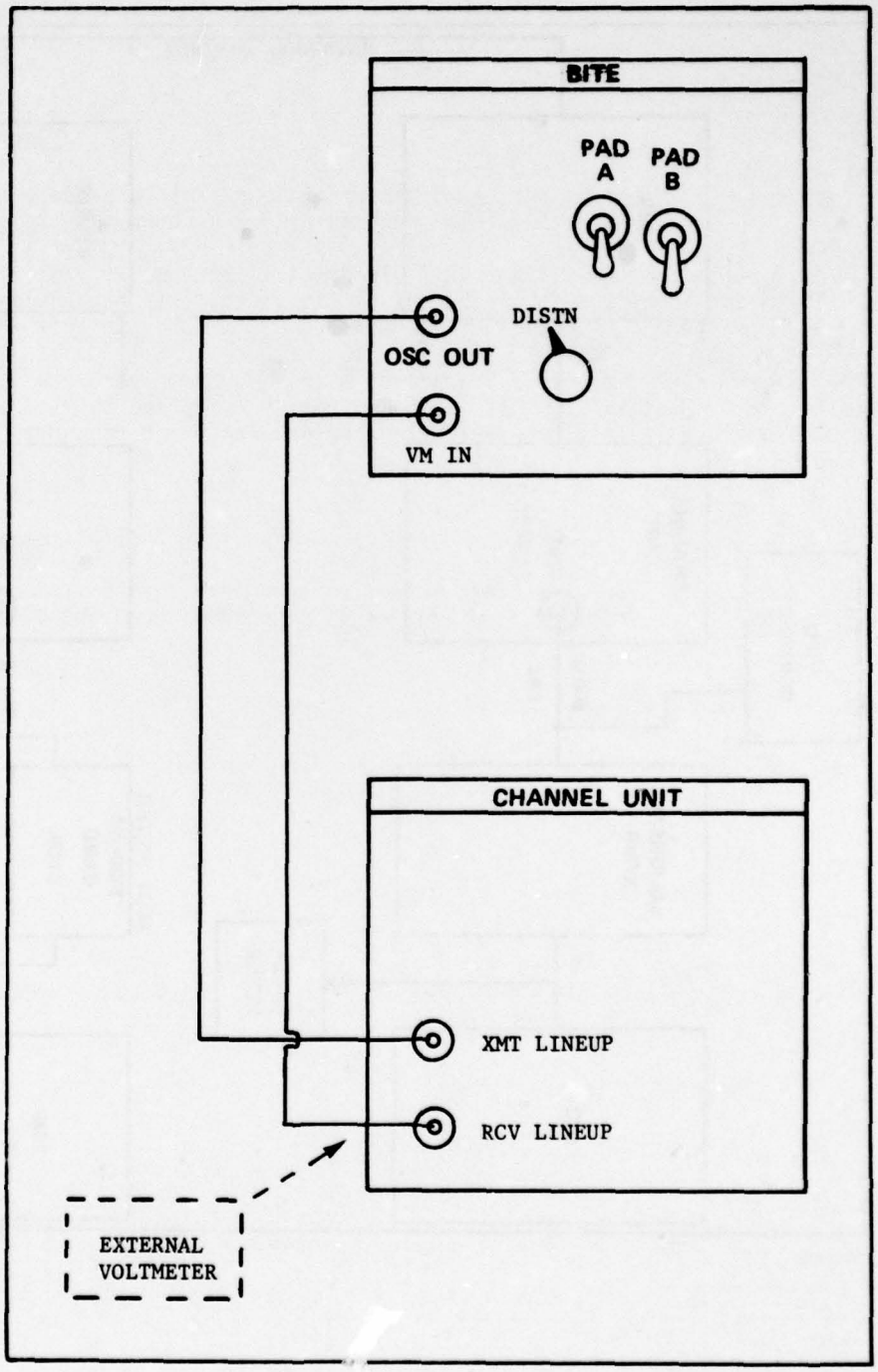


Figure 79-4. Signal-to-noise quantizing test setup using BITE (AN/FCC-98).

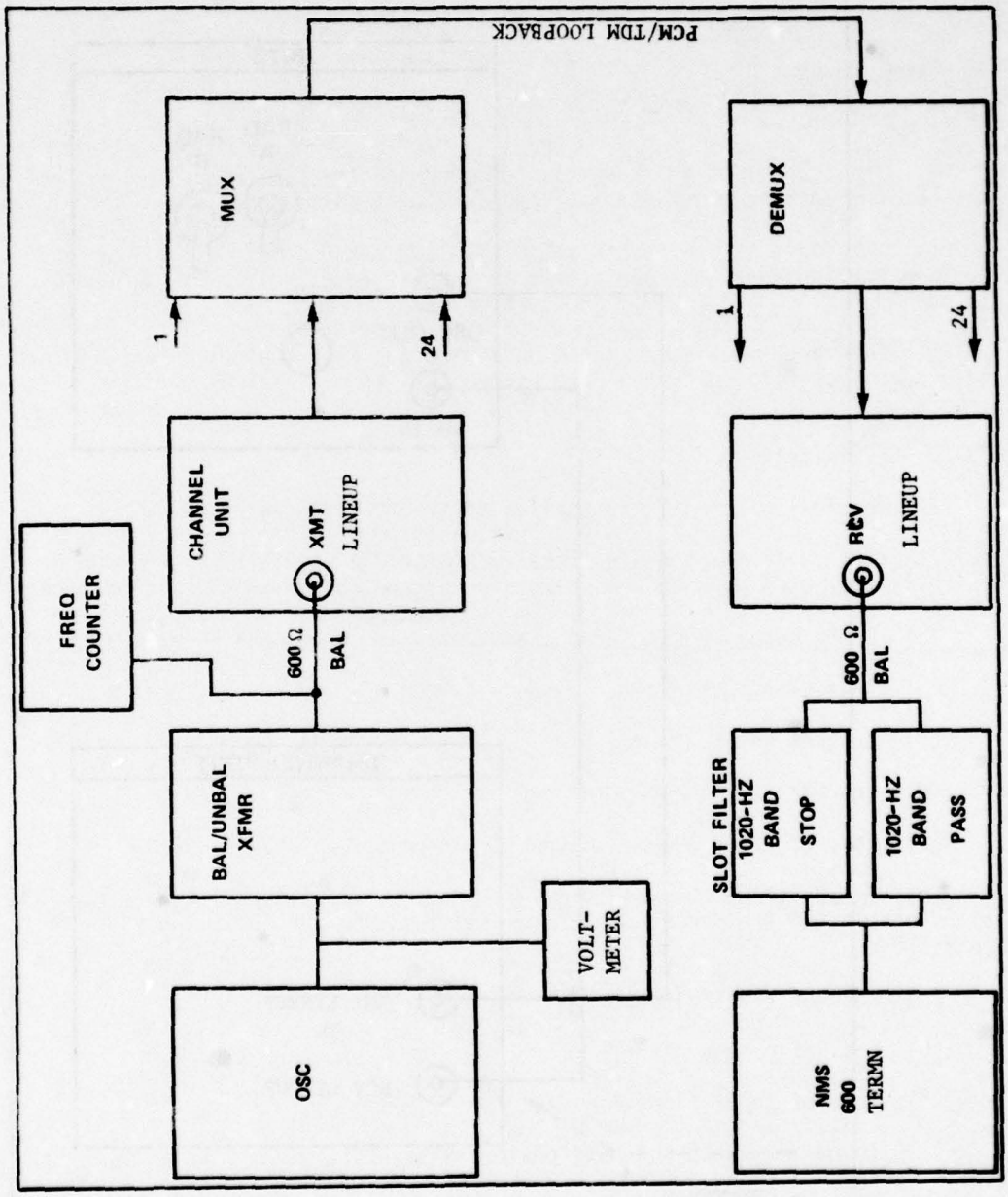


Figure 79-5. Signal-to-noise quantizing (AN/FCC-98) test setup.

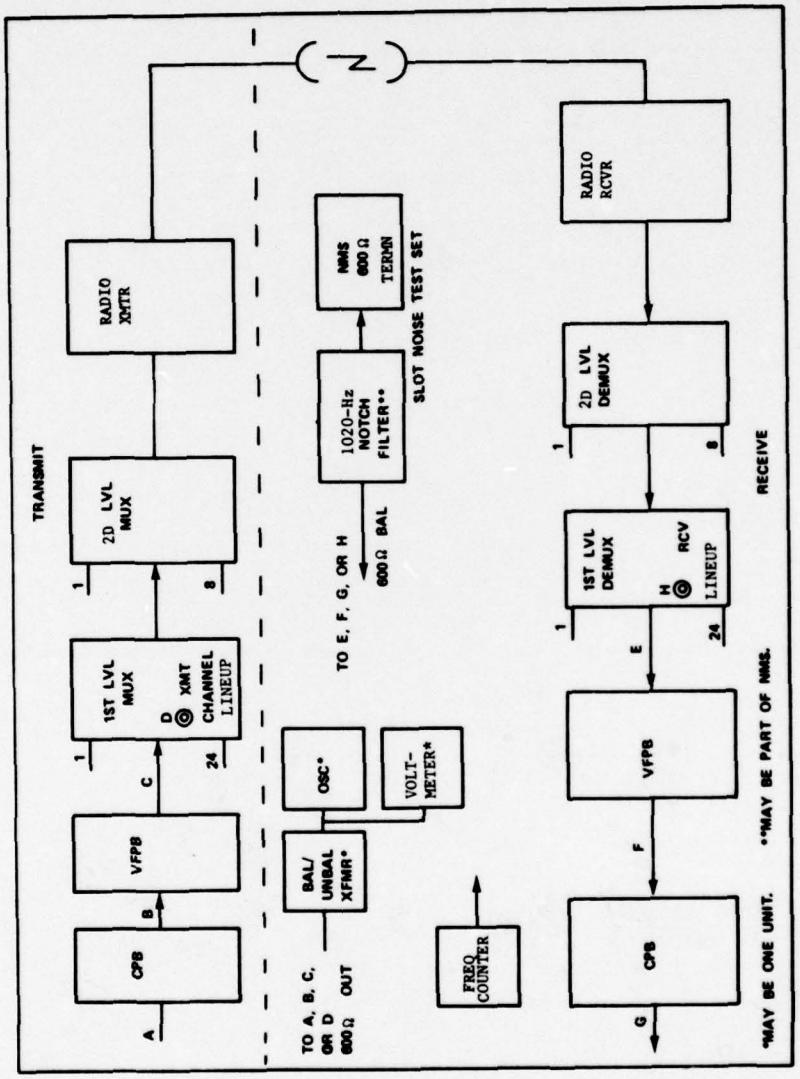


Figure 79-6. Signal-to-noise quantizing end-to-end test setup.

CHAPTER 80

MULTIPLEX TERMINAL END-TO-END COMPATIBILITY AND PERFORMANCE REQUIREMENTS (DT-277)

80-1. GENERAL.

a. The purpose of this test is to determine the multiplex terminal compatibility with other digital equipment and the terminal's end-to-end performance level.

b. This test is applicable to the TD-1192 (AN/FCC-98) multiplex equipment. It may be performed on the AN/FRC-162 and VICOM 4000-2 system; however, there are no applicable performance specifications.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. It would not normally be performed as a routine field test since it is more applicable to initial equipment verification at a contractor's facility.

80-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) The multiplex terminal shall meet the compatibility requirements specified in subparagraph (2), below, when connected end-to-end with a D2 channel bank, a D3 channel bank, or an HY-12 and the multiplex terminal. The interconnecting cable shall be of any length up to and including 750 feet of RG-108A or electrical equivalent.

(2) When interconnected as specified in subparagraph (1), above, the requirements specified in DT-265, DT-266, DT-267, DT-270, DT-273 (8 to 12 pps only), DT-274, DT-275, and DT-276 shall be met. In the event of conflict between the requirements of this paragraph and those of the applicable equipment specification for the D2/D3 channel banks, or HY-12 equipment, the less stringent of the two requirements shall apply for end-to-end connection with the D2/D3 channel banks or HY-12 equipment.

(3) The D2/D3 channel banks shall operate within the requirements specified in tables 80-1 through 80-4.

b. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

80-3. TEST EQUIPMENT REQUIRED. As specified in the individual tests referred to in paragraph 80-2a(2), above.

80-4. TEST PROCEDURES.

a. Connect the equipment to be tested as shown in figure 80-1 and allow approximately 30 minutes for warmup and stabilization.

b. Set up the test equipment and perform the following tests.

TEST TITLE	TEST NO.
Idle Voice Channel Circuit Noise	DT-265
Idle Channel Impulse Noise	DT-266
Voice Channel Crosstalk	DT-267
Voice Channel Intermodulation Distortion	DT-270
E&M Signaling	DT-273
Multiplex Loopback and Loopback Alarm	DT-274
Carrier Group Alarm	DT-275
Signal-to-Noise Quantizing Distortion	DT-276

c. Plot an envelope delay versus frequency curve on figure 3-4 (DD Form 2094).

80-5. DATA RECORDING AND ANALYSIS.

a. Review the individual test results and verify that the compatibility and performance requirements are within specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. If the system or equipment fails to meet specifications, notify the responsible activity of required corrective actions.

Table 80-1. D3 Channel Bank Electrical Input/Output Requirements

INPUT	REQUIREMENT
Line rate	1.544 mb/s ±200 b/s
Line code	Bipolar
Amplitude	±1.5 to 3 volts
Input Impedance	100 ohms
OUTPUT	**REQUIREMENT**
Line rate	1.544 mb/s ±200 b/s
Line code	Bipolar
Line impedance	100 ohms nominal
Pulse Characteristics	
Base-to-peak height	6±0.6 volts
Unbalance in height and positive pulse	±0.3 volt
Half amplitude width	324±30 nsec
Unbalanced in width of positive and negative pulse	±15 nsec
Maximum rise & fall times	80 nsec
Maximum density	Normally 1 in 8, no more than 15 consecutive zeros

Table 80-2. D2 Channel Bank Electrical Requirements

INPUT	REQUIREMENT
Line rate	1.544 mb/s ±50 ppm
Line code	Bipolar
Amplitude	±1.5 to 3 volts
Input Impedance	100 ohms
Input level	-16 dBm
Cable input	Up to 750 feet
OUTPUT	**REQUIREMENT**
Line rate	1.544 mb/s ±50 ppm
Line code	Bipolar
Pulse width	0.30 to 0.34 msec, half amplitude
Amplitude	±6 volts ±10 percent
Line impedance	100 ohms
Level (nominal)	7 dBm
Cable output	Up to 750 feet

Table 80-3. D3 Channel Bank Transmission Requirements

PARAMETER	INPUT POWER (dBm0)	FREQUENCY (Hz)	TWO-WIRE TO TWO-WIRE	FOUR-WIRE (600 Ω)	REMARKS
Bandwidth	0	60	20 dB min	Not specified	Loss relative to 1 kHz
Frequency	0	180	0 to 3 dB	0 to 3 dB	Loss
Response vs	0	300 to 3000	-0.5 to 1.0 dB	-0.25 to 0.25 dB	
Gain/loss	0	3300	--	0 to 1.5 dB	
	0	3400	Not specified	0 to 3 dB	
Longitudinal balance	0	200	66	86	0 dBm0 test tones from 200 to 3400 Hz min. 20 log E_L/E_M
	0	1000	60	80	
	0	3000	58	78	
Impulse noise	--	--	42	10	Terminated channels threshold level (dBrnC0) max counts in 30 minutes
	--	--	52	1	
	--	--	59	0.1	
Echo return	--	1000	28 dB	--	Against 900 ohms 2.5 μF with 25-ohm loop between channel unit and test set
Return Loss	0	1000	--	28 dB	Minimum against 600 ohms
	0	300 to 3000	--	23 dB	
Singing return loss	--	---	20 dB	--	Minimum
Signal-to-distortion	0 to -30	1020	33 dB	--	Minimum with C-message
	-40	1020	27 dB	--	
	-45	1020	22 dB	--	
Loss Stability	--	--	0.25 dB	--	Four-wire PCM
Crosstalk coupling loss	0	--	65 dB minimum	--	0-dBm0 test tones from 200 to 3400 Hz

Table 80-3. D3 Channel Bank Transmission Requirements (continued)

PARAMETER	INPUT POWER (dBm0)	FREQUENCY (Hz)	TWO-WIRE TO TWO-WIRE	FOUR-WIRE (600 Ω)	REMARKS
Single frequency distortion	0	0 to 12 kHz	-28 dBm0	--	For the given frequency range, the output power in any other single frequency shall not exceed the given figure
	0	1.0	40 dBm0	--	The output at any other frequency from 0 to 4 kHz shall be less than this figure
Idle channel noise	--	--	23 dBrnC0	--	Maximum
Tracking	3 to -37	1 kHz	0.5 dB max	--	Average <0.25
	-37 to -50	1 kHz	1.0 max	--	Average <0.5

Table 80-4. D2 Channel Bank Transmission Requirements (Note 1)

PARAMETER	INPUT POWER (dBm0)	FREQUENCY (Hz)	MINIMUM	MAXIMUM	REMARKS
Bandwidth (loss relative to 1 kHz)	0 0 0 0	0.18 0.3 to 3.0 3.3 3.4	0 dB -0.25 dB 0 0	3 dB 0.25 dB 1.5 dB 3 dB	- -
Net loss (stability 3 mo)	0	1	-0.5 dB	+0.5 dB	- -
Delay distortion	0	--	--	--	See figure 80-2
Return loss (against 600 ohms)	0 0	1.0 0.3 to 3.0	28 dB 23 dB	--	- -
Load (loss relative to the loss at 0 dBm0	0 3 5 9	1 1 1 1	-- -- -- --	0 0 1 4.5	- -
S/Nq (dBrnC0) (C-msg)	0 to -30 -40 -45	1.02 1.02 1.02	33 27 22	-- -- --	- -
Single frequency distortion	0 0	0 to 12 1.020	-- --	-28 dBm0 -40 dBm0	See note 2 See note 3
Noise (idle channel)	All channels terminated	--	--	28 dBrnC0	Work channel performance. Typical channel performance will be less than 23 dBrnC0.
Impulse noise	Terminated	--	--	10,1,0,1	Number of counts in 30 minutes not to exceed 10, 1, and 0.1 for thresholds (dBrn0 dB) of 42, 52, 59 respectively

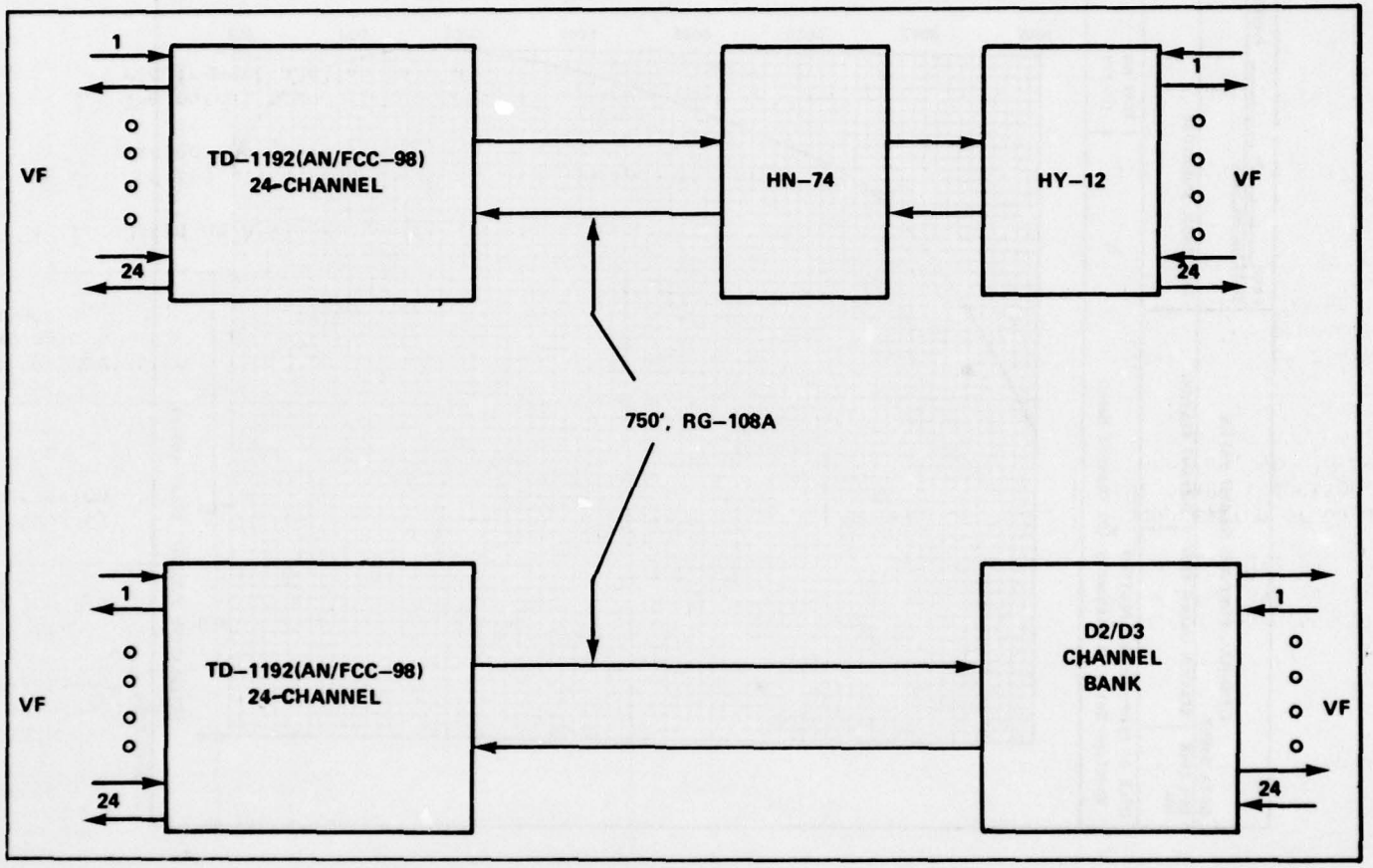
Table 80-4. D2 Channel Bank Transmission Requirements (continued)

PARAMETER	INPUT POWER (dBm0)	FREQUENCY (Hz)	MINIMUM	MAXIMUM	REMARKS
Crosstalk-interchannel and intrachannel	0	0.2 - 3.4	--	25 dBrnC0	- -
Longitudinal balance (20 log E_L/E_m)	0 0 0	0.2 1 3	86 80 78	-- -- --	Source impedance of the longitudinal voltage shall be 0.5 μF
Low frequency suppression	--	--	--	--	Suppression of 60 and 180 Hz power induction, if required, should be available on an optional basis at the 600-ohm system input
Tracking (deviation from gain at 0 dBm0)	3 to -37 -37 to -50 -50 to -54	1 1 1	-0.5 -1.0 -3.0	0.5 1.0 3.0	Deviation for a single link. The overage of many links shall be half this value.

NOTES: 1. Based on AT&T D2 specifications.

2. For the given range of input frequencies, the output power in any other single frequency shall not exceed the given figure.

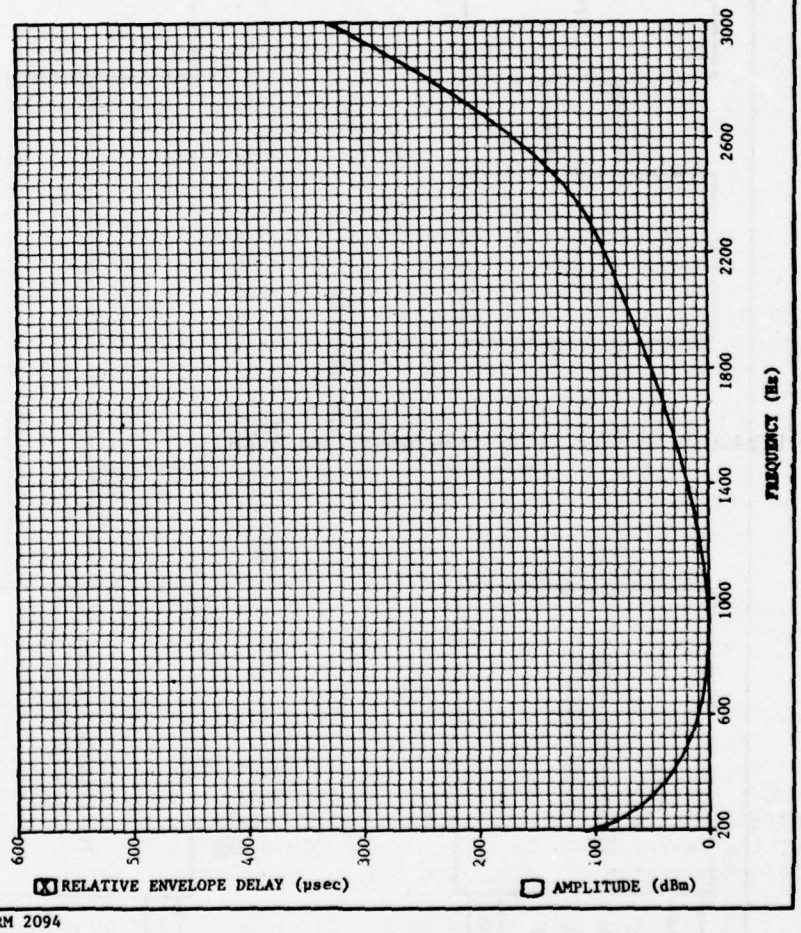
3. The output power at any other frequency from 0 to 4 kHz shall be less than this figure. This requirement applies only at the time of alinement.



CCP 702-11

Figure 80-1. Multiplex terminal end-to-end compatibility test setup.

GENERAL PURPOSE GRAPH PAPER DATA SHEET			PAGE_____ OF _____ PAGES DATE(day,mo.,year)
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE
TITLE OF PERFORMANCE PLOTTED Envelope Delay vs Frequency (D2 Channel Bank)			TEST NO. DT-277



DD FORM 2094

Figure 80-2. Typical envelope delay vs frequency curve (D2 channel bank).

CHAPTER 81

VOICE FREQUENCY CHANNEL INPUT/OUTPUT IMPEDANCES (AUTOMATIC METHOD) (DT-278)

81-1. GENERAL.

a. The purpose of this test is to determine by means of automatic sweep measurements the input and output impedances of voice frequency channels or other audio equipment with a design impedance of approximately 600 ohms.

b. When a load of other than the design impedance is connected to a source, the voltage across the load changes in proportion to the change of the load impedance from the design characteristics. This voltage change can be conveniently read on a dB scale calibrated for 600 ohms or some other impedance and the results correlated to the measured impedance value.

c. This is not a precise measurement, since its accuracy is affected if either the generator impedance or the impedance being measured is reactive (unless both have the same impedance angle). However, since most of the impedances to be measured are expected to have reasonably low angles and because of the simplicity of this procedure, it is considered to be accurate enough for determining the input/output impedances. The voice channel impedance measurements are made at the transmit and receive ends of the voice channel.

d. A transmission line or interface equipment is normally terminated in its characteristic impedance. A mismatch in impedance produces a discontinuity to the normal propagation of the voltage and current waves and gives rise to the reflection of a portion of the incident waves. The reflected waves may result in conditions such as singing, distortion, signal attenuation, or gain and echo. Reflected waves on a communications channel appear as echos to the user. The magnitude of echo signals is determined by the overall circuit loss sustained by a signal traveling through the transmission facilities to the distant termination and/or intermediate points of impedance mismatch and returning to the signal source.

e. This test may be performed at the circuit patch bay, VFPB, or directly at the input/output of the multiplex channels. If performed at the circuit patch bay, signaling and conditioning equipment must be bypassed to preclude erroneous test results. Normally, if performed to verify equipment design at a contractor's facility, the test would be performed directly at the input/output of the device being tested. During field test activities it would normally be performed at the circuit patch bay.

f. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. Since it is

primarily a design verification test, it may be desirable to only perform the test on a sampling basis during field test activities.

81-2. SPECIFICATIONS.

a. The audio input and output impedances of a nominal 4-kHz channel of a long haul or tactical TDM/PCM reference voice bandwidth link shall each be 600 ohms (balanced to ground) with a minimum return loss of 26 dB against a 600-ohm resistance over the frequency bandwidth from 300 to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. (MIL-STD-188-100)

b. The voice frequency input and output impedances of the TD-1192 (AN/FCC-98) shall each be 600 ohms ±10 percent (balanced to ground) with a minimum return loss of 23 dB against a 600-ohm resistive load over the frequency bandwidth from 300 to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. (CCC-74047)

c. The audio inputs/outputs (balanced to ground) of the AN/FRC-162 and VICOM 4000-2 system shall exhibit a minimum return loss of 26 dB against 600-ohm resistance over the frequency range from 300 to 3400 Hz. The longitudinal balance shall be greater than 40 dB.

d. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

81-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Voltmeter.

c. Delay measuring set.

d. Logarithmic/linear amplifier.

e. X-Y recorder.

f. 600-ohm precision terminating resistors.

g. Frequency selective voltmeter (optional).

81-4. TEST PROCEDURES.

a. Complete the top portion of figure 81-1 (DCA Form (Test) G-3) changing the SG and GP columns to read 1st level multiplexer and 2d level multiplexer.

b. Connect the test equipment as shown in figure 81-2a and allow approximately 30 minutes for warmup and stabilization. Use an external 1-percent or better precision termination to initially establish the calibration of the sweep oscillator. Set the output of the delay measuring set to 1020 Hz at 0 dBm0 for nonoperational systems and to -10 dBm0 for systems carrying operational traffic. If the test is conducted on an operational system at the circuit patch bay and the reference test tone level is 0 dBm, then the output of the delay measuring set (into a 600-ohm load) should be set 10 dB below 0 dBm. If the test is conducted at the VFPB and the reference test tone level is -16 dBm, then the output of the delay measuring set should be set 10 dB below -16 dBm (-26 dBm).

NOTE: As a precautionary measure, the idle channel output should be checked to ensure that no other signals, including crosstalk, are present in the channel, which might interfere with readings being taken. If the test is conducted at other than the circuit patch bay, be sure to appropriately readjust the tone level output of the delay measuring set. In this connection, the actual level used is not critical, within limits, but must be known exactly. Therefore, it may not be necessary to readjust each time the test equipment is moved to a different test point as long as the level does not exceed the dBm0 reference level for the equipment test point.

c. Load the X-Y recorder with the appropriate graph paper (fig. 81-1 (DCA Form (Test) G-3) and calibrate the horizontal (X) axis by varying the output frequency of the delay measuring set between 100 and 4000 Hz for normal channel measurements. Adjust the recorder as required. Return the delay measuring set to 1020-Hz output. Calibrate the vertical (Y) axis of the recorder by varying the output level of the delay measuring set between 1.5 and -2.5 dB from the 0- or -10 dBm0 reference level as read on the external voltmeter. Return the output level of the delay measuring set to the reference level. Set the frequency to the low end of the spectrum to be used and perform a sweep with the 600-ohm 1-percent termination connected. The recorder level should not vary more than ±0.15 dB throughout the sweep. A greater variation would indicate an equipment malfunction such as nonlinearities in the sweep oscillator, improper recorder tracking, or a questionable termination. If this situation occurs, discontinue the automatic method and use the manual method described in DT-279.

d. Disconnect the external precision termination and connect the output of the delay measuring set to the test point to be tested as shown in figure 81-2b. If the test is to be performed on a link basis or in a back-to-back configuration, terminate the receive side in its characteristic impedance. Do not readjust the delay measuring set to the dBm0 reference level during the subsequent procedures.

e. Sweep the delay measuring set across the frequency band of interest and record the input level on the X-Y recorder plot. The sweep rate of the delay measuring set must be low enough so that the X-Y recorder will track any abrupt changes.

f. Repeat subparagraphs d and e, above, for the remaining measurements to be performed on the equipment input terminals.

g. Repeat the entire test procedure for the output test points (receive end) of each channel or system being evaluated. Insert the tone backwards; that is, into the output of the channel with the receive end terminated. As a precautionary measure check the idle channel output to ensure that no other signals are present which could interfere with the test results.

NOTE: Since this is primarily a diagnostic routine, the onsite NCOIC or quality assurance personnel may elect to perform the test only to isolate a problem or as a sampling of equipment performance.

h. For a list of the deviations (in dB) from the nominal 600-ohm value for a range of load impedances between 400 and 800 ohms, refer to table 81-1.

Table 81-1. Voice Frequency Channel Impedance Deviations

DEVIATION (-dB)	VF CHANNEL IMPEDANCE (ohms)	DEVIATION (+dB)	VF CHANNEL IMPEDANCE (ohms)
1.94	400	0.14	620
1.69	420	0.28	640
1.45	440	0.40	660
1.23	460	0.53	680
1.02	480	0.64	700
0.83	500	0.76	720
0.64	520	0.86	740
0.47	540	0.97	760
0.30	560	1.06	780
0.15	580	1.16	800
0.0	600		

i. Repeat the above procedures for each input/output impedance measurement requirement.

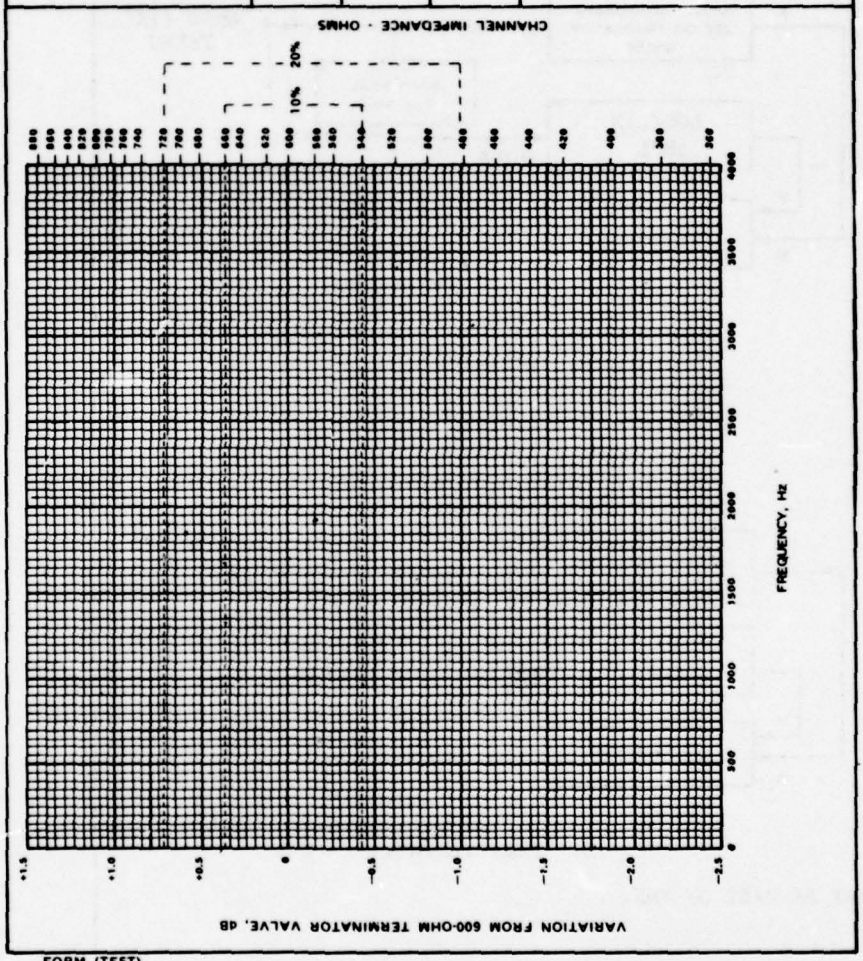
81-5. DATA RECORDING AND ANALYSIS.

a. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

CHANNEL IMPEDANCE				PAGE _____ OF _____ PAGES
DATA SHEET G-3				DATE (day, mo., year)
DCS LINK NO.	STATION UNDER TEST			TEST ENGR. SIGNATURE
TEST POINT TP— _____	SG	GP	CH	



DCA FORM (TEST) G-3 MAR 73

Figure 81-1. Voice frequency channel impedance data sheet.

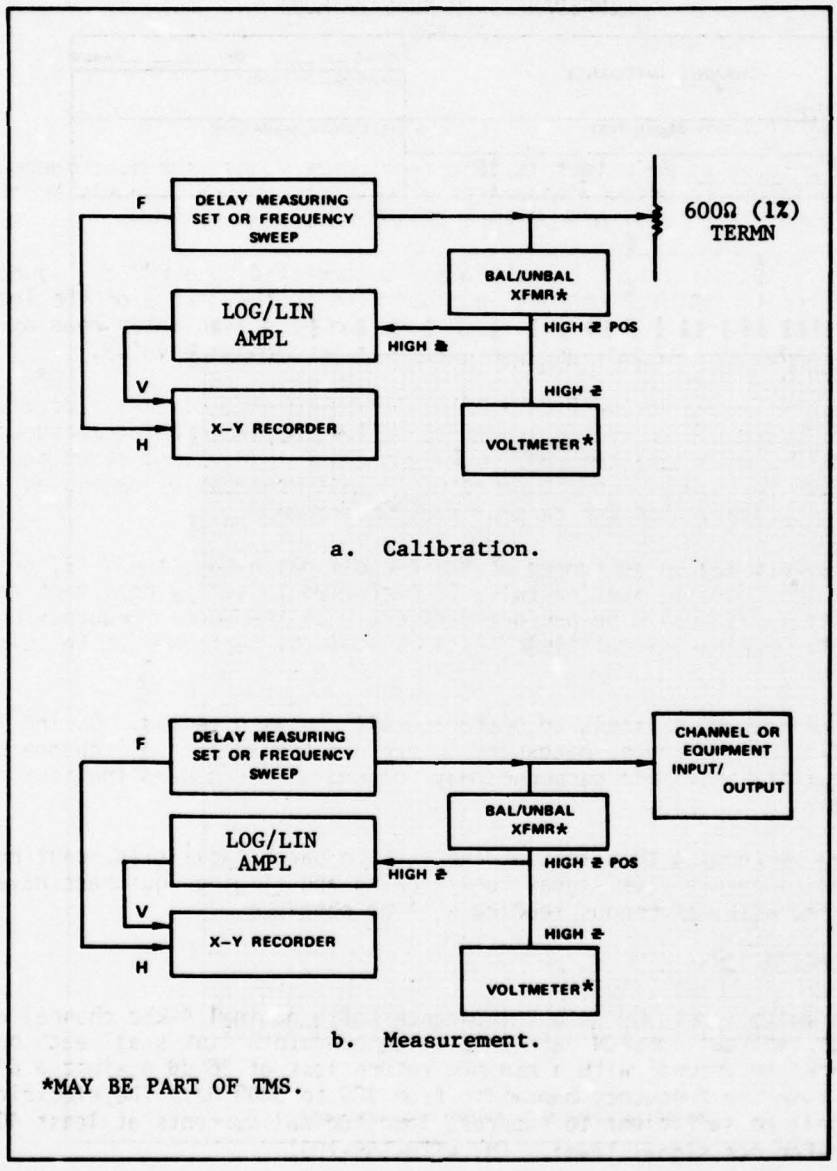


Figure 81-2. Voice frequency channel impedance (automatic method) test setup.

CHAPTER 82

VOICE FREQUENCY CHANNEL INPUT/OUTPUT IMPEDANCES (MANUAL METHOD) (DT-279)

82-1. GENERAL.

a. The purpose of this test is to determine by means of manual sweep measurements the input and output impedances of voice frequency channels or other audio equipment with a design impedance of approximately 600 ohms.

b. When a load of other than 600 ohms is connected to a 600-ohm source, the voltage across the load changes in proportion to the change of the load impedance from 600 ohms. This voltage change can be conveniently read on a dB scale calibrated for 600 ohms and correlated to an impedance value.

c. This test does not provide a precise measurement, since its accuracy is affected if either the generator impedance or the impedance being measured is reactive (unless both have the same impedance angle). However, since most of the impedances to be measured are expected to have reasonably low angles, it is considered accurate enough for general field measurements.

d. This test may be performed at the circuit patch bay, the VFPB, or directly at the channel input/output. If performed to verify equipment design characteristics, it should be performed directly at the voice frequency channel input/output. During general field tests it would be performed at the circuit patch bay.

e. The number of channels to be tested will be as directed. During initial installation, it may be necessary to perform the test on all channels. Follow-on quality assurance personnel may perform a random sampling test of the channels.

f. When performing this test at the station patch facilities, caution must be exercised to ensure that signal conditioning and ringing equipment have been bypassed; otherwise, erroneous reading will be obtained.

82-2. SPECIFICATIONS.

a. The audio input and output impedances of a nominal 4-kHz channel of a long haul or tactical TDM/PCM reference voice bandwidth link shall each be 600 ohms (balanced to ground) with a minimum return loss of 26 dB against a 600-ohm resistance over the frequency bandwidth from 300 to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. (MIL-STD-188-100)

b. The voice frequency input and output impedances of the TD-1192 (AN/FCC-98) shall each be 600 ohms ±10 percent (balanced to ground) with a minimum return loss of 23 dB against a 600-ohm resistive load over the frequency bandwidth from 300 to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. (CCC-74047)

c. The audio inputs/outputs (balanced to ground) of the AN/FRC-162 and VICOM 4000-2 system shall exhibit a minimum return loss of 26 dB against 600 ohm resistance over the frequency range from 300 to 3400 Hz. The longitudinal balance shall be greater than 40 dB.

d. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

82-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Voltmeter.

c. Balanced/unbalanced transformer.

d. Precision terminations 600 ohms, 1 percent.

e. Hybrid transformer.

f. 300-ohm 1-percent resistors.

g. Frequency selective voltmeter.

82-4. TEST PROCEDURES. Repeat the applicable procedures for each channel to be tested.

a. Primary Method.

(1) Complete the top portion of figure 16-4 (DD Form 2095).

(2) Connect the test equipment as shown in figure 82-1a and allow approximately 15 minutes for warmup and stabilization.

(3) With the oscillator feeding into an external 600-ohm 1-percent termination, calibrate the input signal to the 600-ohm load by adjusting the oscillator to 1020 Hz at -10 dBm0 for operational systems and 0 dBm0 for non-operational systems. If the test is conducted at the circuit patch bay and the reference test tone level is 0 dBm, then the output power of the oscillator, as

measured by the voltmeter into a 600-ohm load, should be set 10 dBm below 0 dBm (-10 dBm). If the test is conducted at the VFPB and the reference test tone level is -16 dBm, then the output of the oscillator should be set 10 dB below -16 dBm (-26 dBm).

(4) Disconnect the external 600-ohm termination and connect the oscillator output to the input of the voice channel or other desired test points as shown in figure 82-1b. The receive end of the voice channel should be terminated in a 600-ohm load at the channel output terminals.

(5) Do not readjust the oscillator during the subsequent procedures.

(6) Vary the oscillator output frequency in steps as shown on the figure 16-4 (DD Form 2095). Record the test signal power level (in dBm) as read on the voltmeter. Record this information on the data sheet. Calculate the test tone variance from the 600-ohm loaded value in dB. An adequate frequency spread must be used in order to obtain sufficient points for plotting a smooth curve on figure 81-1 (DCA Form (Test) G-3). Take all readings to a 0.1-dB accuracy or better to ensure that a valid assumption can be made as to the impedance over the frequency spectrum. (Except for exactly 600 ohms or some other design impedance, the readings will not be in true power. For the purpose of this test we will refer to them as dBm.

(7) Record all data on figure 16-4 (DD Form 2095) and plot the tone variations in dB versus frequency on figure 81-1 (DCA Form (Test) G-3). Connect the test points with a smooth curve exercising caution not to obliterate any of the data points.

(8) Repeat the entire test procedure for the inputs of other voice channels or test points to be tested. For test points other than voice frequency channels, ensure that the proper termination is used and that it is compatible with the equipment design.

(9) Repeat the entire test procedure for the output (receive end) of each voice channel or test point to be tested. In this case the tone will be inserted backwards; that is, into the output of the channel with the receive end terminated in its characteristic impedance. As a precautionary measure, check the idle channel output to ensure that no other signals are present which might result in erroneous readings.

(10) For a list of deviations (in dB) versus channel impedance, refer to table 81-1.

b. Alternate Method. An alternate test setup is shown in figure 82-2. This technique was used on the original acceptance of the European digital systems; therefore, if trying to duplicate original test results, this method should be used.

(1) If the impedance under test is the channel output, ensure that there are no signals such as test tones, pilots, etc., that would invalidate the test data.

(2) Adjust the oscillator for 1020 Hz with the switch in position 1. Adjust the output level of the oscillator for 0 dBm0 for nonoperational systems or -10 dBm0 for systems carrying traffic.

NOTE: Verify channel input and output strapping levels in accordance with the equipment technical manual.

(3) Disconnect the HP 3591A across the A-A1 connection and adjust the sensitivity and tuning of the frequency selective voltmeter as required across the 300-ohm resistor to give a convenient reading in dB. Note this reading as load L1.

(4) Operate the switch to position 2 and note the reading on the frequency selective voltmeter at B-B1. Note this reading as load L2.

(5) The return loss of the impedance under test is the difference between the readings (L2 - L1). Record this value on figure 16-4 (DD Form 2095).

(6) Repeat the above procedures at the frequencies shown on the data sheet.

82-5. DATA RECORDING AND ANALYSIS.

a. Plot the test data entered on figure 16-4 (DD Form 2095) onto the graph shown in figure 81-1 (DCA Form (Test) G-3). Review all test results for compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and return the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

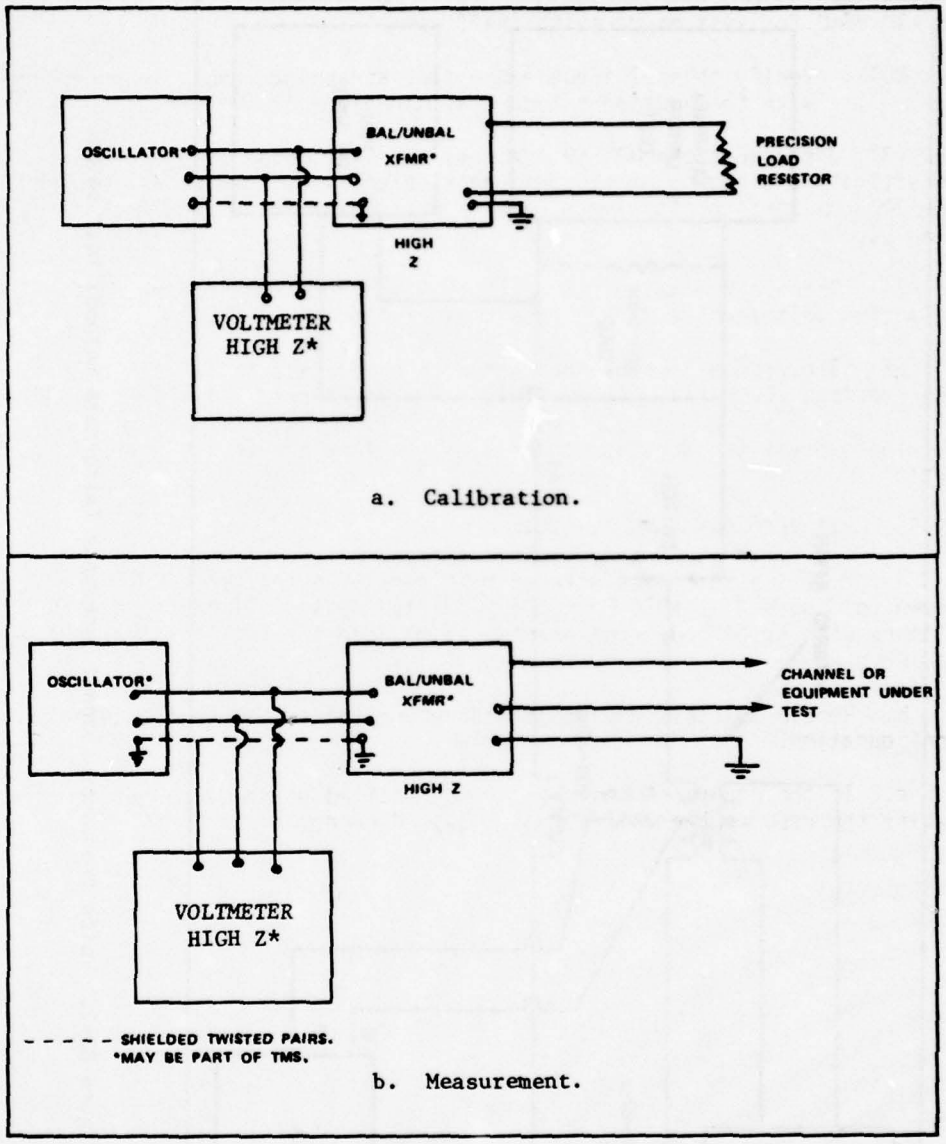


Figure 82-1. Voice frequency channel impedance (primary method) test setup.

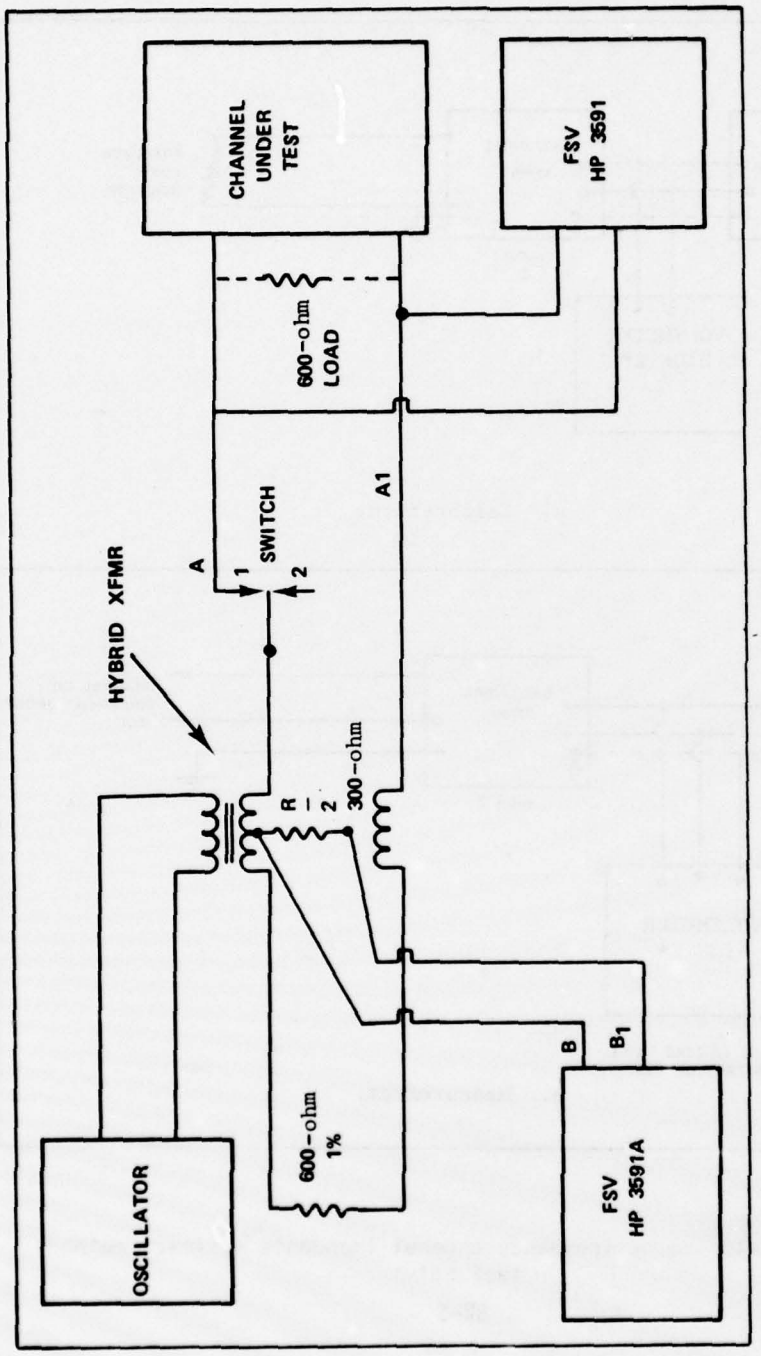


Figure 82-2. Voice frequency channel impedance (alternate method) test setup.

CHAPTER 83

IMPEDANCE MEASUREMENTS (BRIDGE METHOD) (DT-280)

83-1. GENERAL.

a. The purpose of this test is to determine the impedance at important interface points within a system. This test differs from DT-278 and DT-279 in that an impedance bridge is used to determine if any irregularities exist within the system.

b. The method to be used for impedance measurements will depend on equipment availability or requirements or as directed by the team chief. An important factor to remember, however, is that different test configurations will invariably produce different results. Therefore, to duplicate the original test results, it is essential that the same test setup be used.

c. This test method uses a standard AC bridge to measure the impedance at various test points within the equipment. Normally, the impedance of transmission system inputs and outputs should be measured at the test tone level used at the input test point in the system. On operational systems, common practice is to use a test tone 10 dB down from the designed input level. For nonoperational systems, the test tone used should be the same as the designed input level and 10 dB down from this level on operational systems.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed or as a diagnostic aid in resolving interface problems.

83-2. SPECIFICATIONS.

a. The audio input and output impedances of a nominal 4-kHz channel of a long haul or tactical TDM/PCM reference voice bandwidth link shall each be 600 ohms (balanced to ground) with a minimum return loss of 26 dB against a 600-ohm resistance over the frequency bandwidth from 300 to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. (MIL-STD-188-100)

b. The voice frequency input and output impedances of the TD-1192 (AN/FCC-98) shall each be 600 ohms ±10 percent (balanced to ground) with a minimum return loss of 23 dB against a 600-ohm resistive load over the frequency bandwidth from 300 to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

c. The audio inputs/outputs (balanced to ground) of the AN/FRC-162 and VICOM 4000-2 system shall exhibit a minimum return loss of 26 dB against a 600-ohm resistance over the frequency range from 300 to 3400 Hz. The longitudinal balance shall be greater than 40 dB. (CCC-74047)

d. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

83-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Impedance bridge.

c. Voltmeter.

d. 600-ohms 1-percent precision resistors.

e. Amplifier (if required).

83-4. TEST PROCEDURES.

a. Complete the top portion of figure 16-4 (DD Form 2095).

b. Connect the test equipment as shown in figure 83-1a for calibration and allow approximately 15 minutes for warmup and stabilization.

NOTE: On some impedance bridges, the transmission measuring set and voltmeter may have equivalent built-in devices. For the voice channel inputs/outputs, the bridge must have a balanced input. In general bridge measurements, the test lead would be an open circuit at point (A) on figure 83-1b, while the bridge zero balance was accomplished. However, the system impedance under test may range from 75 to 900 ohms and for greatest accuracy a different zero balance procedure should be performed as outlined in subparagraph c, below. Due to the wide variation of available impedance bridges, test personnel should consult the equipment instruction manual before conducting the test.

c. Calibrate the bridge by connecting a 600-ohm precision resistor across the test leads of the bridge input and zero balance the bridge according to the operating instructions with the instrument.

NOTE: Some types of bridges are supplied with precision calibrating resistors.

d. Once the zero balance has been accomplished, remove the precision resistor and connect the test equipment as shown in figure 83-1b. Set the oscillator frequency at 1020 Hz at 0 dBm0 on nonoperational systems and -10 dBm0 on operational systems.

e. Set the impedance bridge decades to a rough balance using the transmission measuring set or built-in oscillator. Adjust the oscillator output so that the correct test tone level is applied to the test point under test.

NOTE: The voltmeter may be part of the transmission measuring set, built into bridge, or an external frequency selective voltmeter.

f. Use table 83-1 as a guide in setting the test level over the frequency spectrum of interest. Remove the voltmeter from the test setup once the level has been established.

Table 83-1. Test Tone Guide for Voltmeter

TEST POINT IMPEDANCE (Ω)	75	135	150	600	900
OSCILLATOR OUTPUT (dBm)	Voltmeter (mV)				
0	274	368	387	775	950
-10	87	116	122	245	300
-20	27.4	37	38.7	77.5	95.0
-30	8.7	11.6	12.2	24.5	30.0

g. Change the bridge frequencies to those shown in figure 16-4 (DD Form 2095) and record the impedance as read on the internal bridge meter or the external voltmeter. Record the results on the data sheet.

h. Plot a graph of the test results on figure 81-1 (DCA Form (Test) G-3).

i. Repeat the above test for other channels to be tested.

83-5. DATA RECORDING AND ANALYSIS.

a. Summarize the test results on figure 3-7 (DD Form 2091). Compare the measured results to the requirements specified for the equipment under test.

b. Remove the test equipment and return the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

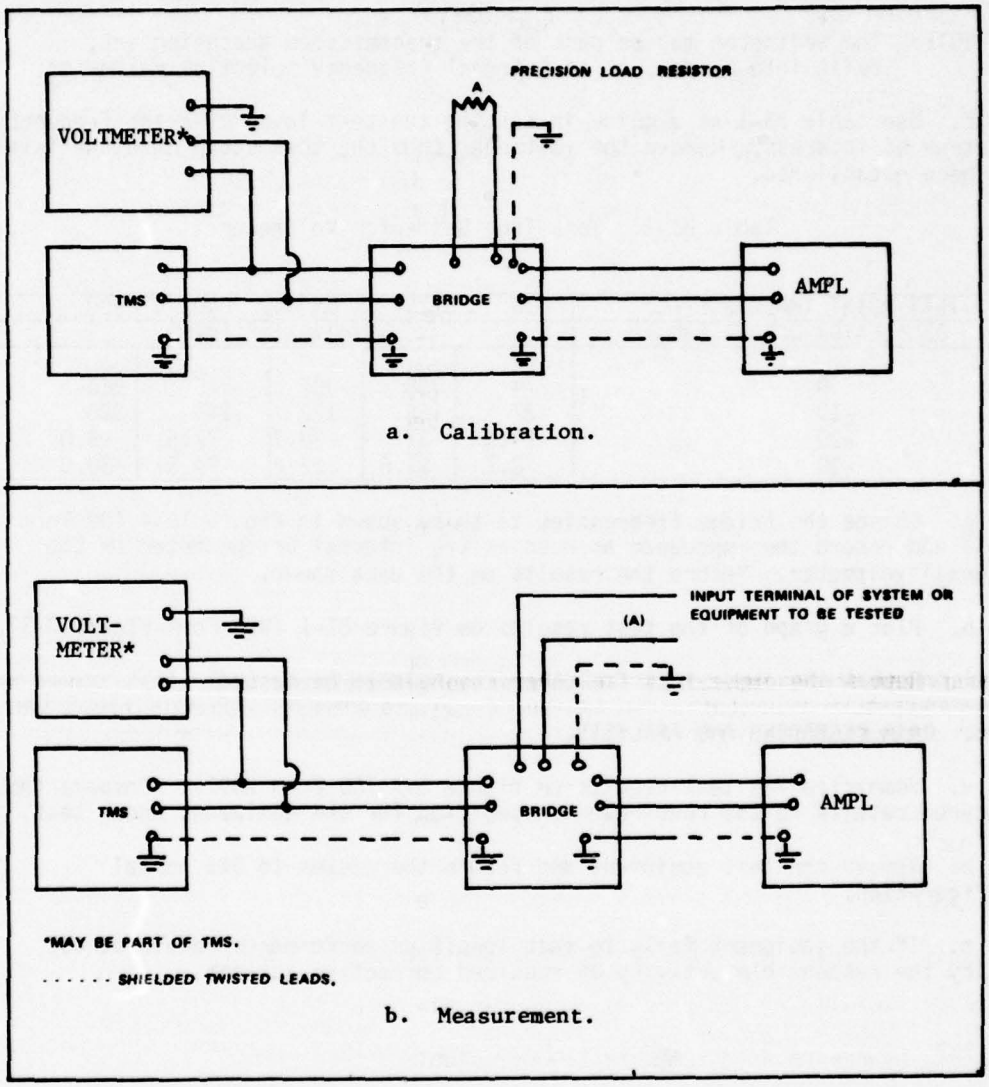


Figure 83-1. Impedance measurements (bridge method) test setup.

CHAPTER 84

VOICE FREQUENCY CHANNEL INPUT/OUTPUT INTERFACE LEVEL (DT-281)

84-1. GENERAL.

a. The purpose of this test is to determine the multiplexer's ability to accept different input levels and to provide different output levels based on strapping options of the equipment. It will also determine the adjustability of the multiplex output level.

b. This test would normally be performed at a contractor's facility to determine if the equipment meets specified performance requirements during production or first article testing. However, it may be performed on contractor EF&I systems to determine if the equipment meets specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities to verify that the multiplex has been properly configured to meet local requirements.

c. This test may be performed at the circuit patch bay, VFPB, or directly at the channel input/output of the equipment under test.

84-2. SPECIFICATIONS.

a. The TD-1192 (AN/FCC-98) multiplexer's normal input level shall be either 0 or -16 dBm, selectable by strapping option. The demultiplexers normal output level shall be either 0 or +7 dBm, selectable by strapping option. Additionally, the output level shall be continously adjustable from +3 to -7 dBm for the 0-dBm output option and from +10 to 0 dBm for the +7 dBm output option. (CCC-74047)

b. The AN/FRC-162 and VICOM 4000-2 system (AN/FCC-97) shall operate as follows:

(1) Two-wire 0 dBm transmit -- adjustable +2 to -5 dBm.

(2) Four-wire -16 dBm transmit -- adjustable 0 to -16 dBm.

(3) Two-wire -2 dBm receive -- adjustable 0 to -5 dBm.

(4) Four-wire +7 dBm receive -- adjustable 0 to +8 dBm.

c. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCA 300-175-9; app C)

d. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

84-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Voltmeter.

c. Balanced/unbalanced transformer.

84-4. TEST PROCEDURES.

a. This test may be performed on a link or loop basis as shown in figures 84-1 and 84-2.

b. Connect the test equipment as shown in figure 84-1 or 84-2 and allow approximately 30 minutes for warmup and stabilization.

c. On the voice frequency channel module, verify that the input/output level strapping options have been configured for the level at which the test will initially be performed. Also verify that the units are strapped for two- or four-wire operation.

d. For a voice frequency input of 0 dBm:

(1) Adjust the transmission measuring set for 1020 Hz at 0-dBm output as read on the internal voltmeter. Set the oscillator to 600 ohms bananced output. If the transmission measuring set does not have a balanced output, use a balanced-to-unbalanced transformer.

(2) Connect the transmission measuring set to the receive channel output and terminate the transmission measuring set into 600-ohm balanced position. Measure the 0-dBm tone. The measured level should be 0 dBm ±0.5 dB. If not, the channel and digroup levels should be alined.

(3) On the receive channel module, adjust the gain and verify that the level is adjustable over the range specified in paragraph 84-2 a or b, above. Record the results on figure 84-3 (USACC Form 664-R).

e. For a voice frequency input of -16 dBm:

(1) Connect the appropriate straps on the multiplex terminal for a -16 dBm input and a +7 dBm receive output.

(2) At the transmit multiplex, set the transmission measuring set oscillator to 1020 Hz at an output level of -16 dBm.

(3) At the receive terminal, measure the level of the transmitted test tone. The level should be +7 dBm ±0.5 dB. If not, aline the channel module and digroup levels as required.

(4) At the receive terminal, adjust the voice frequency channel module receive gain adjust from 0 dBm to +10 dBm as read on the transmission measuring set dB meter. Continue to adjust the receive gain potentiometer over its full range and record the results on the data sheet.

NOTE: The built-in test oscillator and dB meter of the multiplex equipment should not be used for this test due to possible nonlinearities of the built-in meter.

f. Repeat the above procedures for other channels to be tested. Reverse the direction of transmission and repeat the procedure for the opposite direction of transmission.

84-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and verify that the equipment meets specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

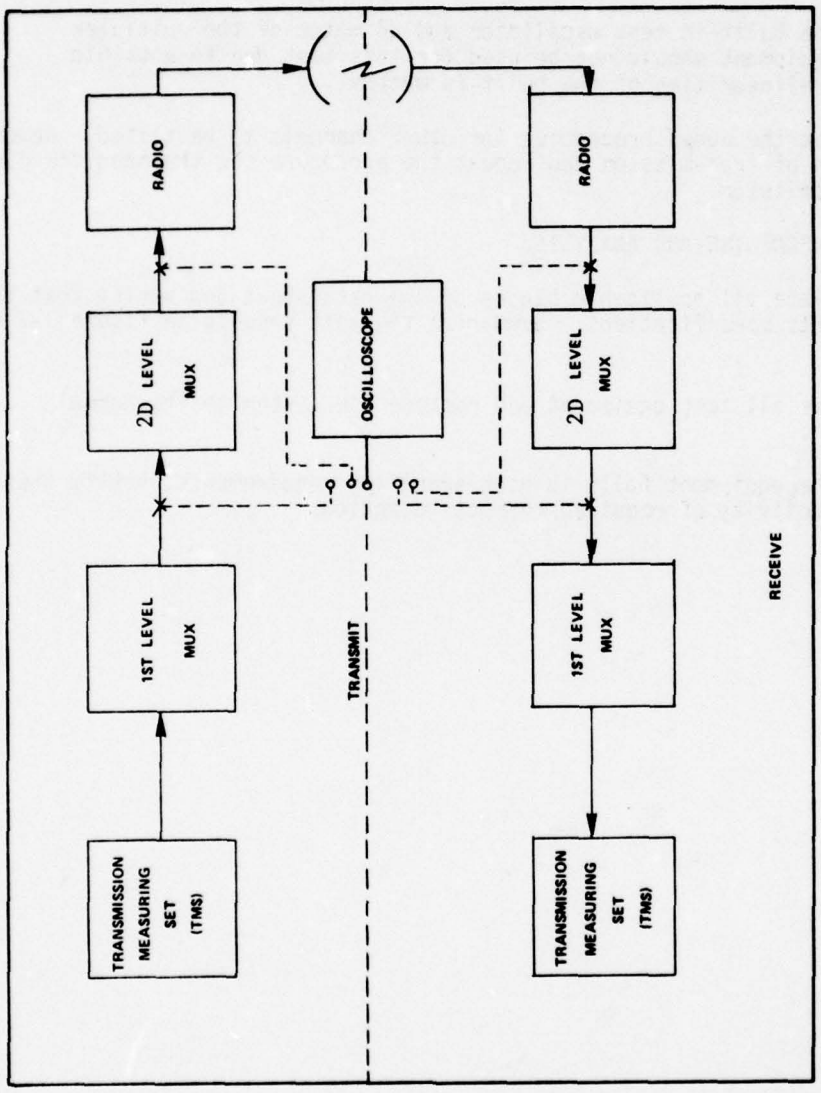


Figure 84-1. Voice frequency channel input/output interface (link) test setup.

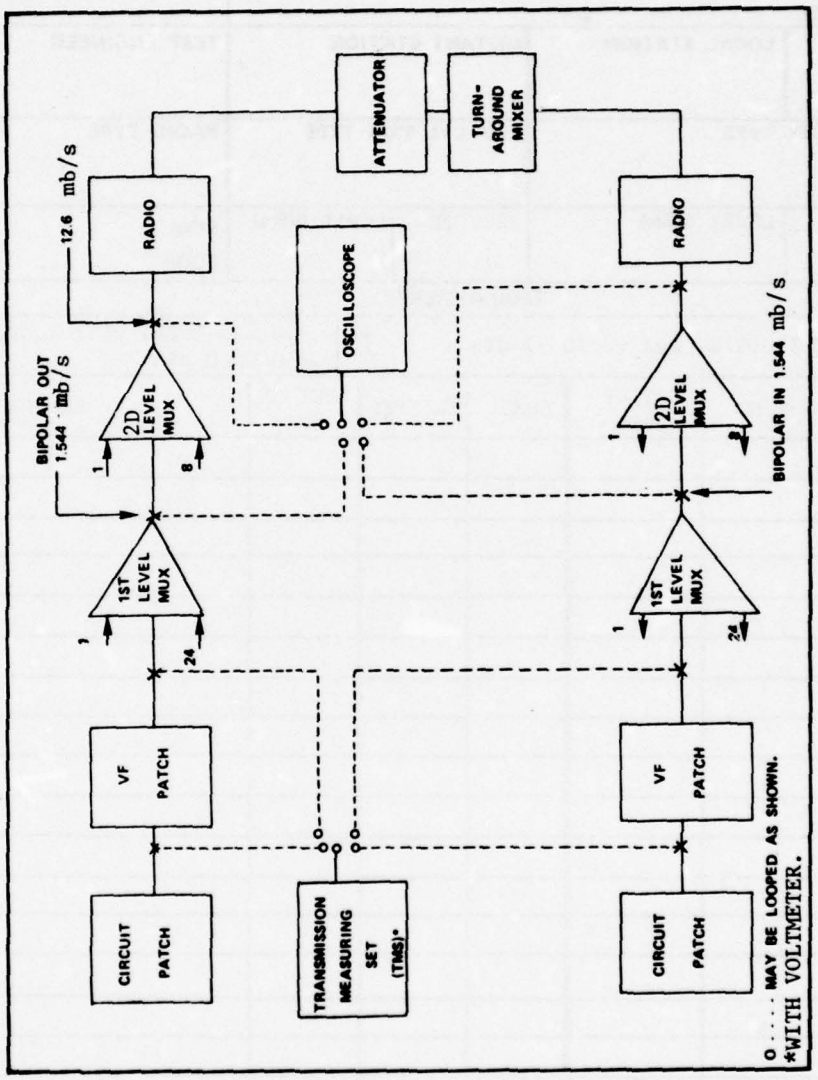


Figure 84-2. Voice frequency channel input/output interface (loop) test setup.

VOICE FREQUENCY CHANNEL INPUT/OUTPUT LEVEL INTERFACE (CCR 702-1-3) DATA SHEET				PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION		TEST ENGINEER
1ST LVL MUX TYPE		2D LVL MUX TYPE		RADIO TYPE
XMT TP	LEVEL (dBm)	RCV TP	LEVEL (dBm)	LINK ☐ LOOP ☐

REQUIREMENTS	
0 dBm INPUT-OUTPUT ADJ +3 TO -7 dBm ☐	-16 dBm INPUT-OUTPUT ADJ +10 TO 0 dBm ☐

CHAN	IN SPEC	OUT OF SPEC	CHAN	IN SPEC	OUT OF SPEC	REMARKS

USACC FORM 664-R
1 MAY 79

Figure 84-3. Voice frequency channel input/output interface data sheet.

CHAPTER 85

VOICE FREQUENCY CHANNEL INPUT/OUTPUT LINEARITY (DT-282)

85-1. GENERAL.

a. The purpose of this test is to determine the voice frequency channel input/output linearity over a range of input signals.

b. This test determines the tracking capability of the multiplex and demultiplex, especially the coder and decoder circuits, and is sometimes referred to as a compression expansion linearity test.

c. Pulse code modulation digital multiplexers incorporate circuitry to amplify lower signal levels prior to encoding. This circuitry compresses the size of the code steps such that, where a given sample amplitude change would traverse only two amplitude steps, it now traverses five code steps. At the receive end, the receive code is expanded to reproduce the correct input signal amplitude. This compression-expansion function can be performed by a discrete circuit designated as the compander and results in the signal-to-distortion (quantizing) ratio becoming almost independent of signal level. This test is performed on only a few of the 24 channels per digroup due to the commonalty of the compander circuitry to all 24 channels.

d. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

e. The number of channels to be tested will be as directed; however, if not stated an adequate number should be tested to obtain a high confidence level that the equipment is functioning properly. If performed during initial equipment acceptance from a contractor's facility, all channels should be tested.

85-2. SPECIFICATIONS.

a. As a design objective, the input/output level characteristics of a nominal 4-kHz channel of a long haul TDM/PCM reference voice bandwidth link shall be linear within ±0.5 dB for input signals from -16 to -53 dBm and -67 dBm; and ±3 dB for input signals between -67 and -70 dBm. At an input level of -11 dBm, the output level shall not be greater than +11.2 dBm. (MIL-STD-188-100)

b. Each channel of the TD-1192 (AN/FCC-98) when measured from a four-wire voice frequency input to a four-wire voice frequency output at a 1020±5 Hz test tone shall be linear within: (CCC-74047)

RANGE OF INPUT SIGNALS (dBm0)	DEVIATION (dB)
From +3 down to -37	±0.5
From -37 down to -50	±1.0
From -50 down to -55	±3.0

c. The AN/FRC-162 and VICOM 4000-2 system shall be linear within ±1 dB from +3 to -50 dBm0.

d. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

85-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Voltmeter.

c. Balanced-to-unbalanced transformer.

d. Frequency counter.

85-4. TEST PROCEDURES.

a. Perform this test at the circuit patch bay, the VFPB, or directly at the channel input/output terminals. If conducted as a part of initial equipment acceptance, it should be performed directly at the channel to preclude any loss or interference with the test results by external station cables and equipment.

b. Connect the test equipment for calibration as shown in figure 67-1 and allow approximately 30 minutes for warmup and stabilization. Terminate the transmission measuring set output into a 600-ohm balanced load 1-percent or better terminating resistor.

c. With the frequency counter, establish a 1020-Hz 0-dBm0 test tone from the transmission measuring set. Starting at a +3 dBm0 output, slowly adjust the oscillator output over the level from +3 to -55 dBm0. The output should be flat within ±0.1 dB.

d. At the receive end voice frequency channel output, connect the equipment to the four-wire output terminals of the channel under test (fig. 67-1 or 84-2). The transmission measuring set must be placed in the 600-ohm balanced and terminated position.

e. At the transmit end, insert a 0-dBm0 test tone into the four-wire transmit of the channel under test and at the recive end measure and record the received tone level. If the received tone is not within ±0.5 dB, the channel, group, and 2d level multiplex should be checked for proper alinement.

f. At the transmit end, set the 1020-Hz test tone output to +3 dBm0, and at the receive four-wire output measure, and record the test tone level. In turn change the transmit end output to the levels shown on figure 85-1 (USACC Form 665-R). At the receive end, measure and record the receive four-wire output level on the data sheet.

g. Reverse the direction of transmission and repeat the entire test for each channel to be tested in the opposite direction of transmission.

85-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and verify that the channels tested met the performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

VF CHANNEL INPUT/OUTPUT LINEARITY (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

EQUIP TEST POINTS AND REFERENCE LEVELS										
TP NO.	TP			TP			LINK ☐ LOOP ☐			TYPE MUX
REF LVL	dBm			dBm						
CHAN NO.	TRANSMIT LEVELS (dBm0)									
	+3	0	−10	−16	−27	−37	−45	−50	−55	
	RECEIVE LEVELS (dBm0)									

USACC FORM 665-R
1 MAY 79

Figure 85-1. VF channel input/output linearity data sheet.

CHAPTER 86

VOICE FREQUENCY CHANNEL LEVEL STABILITY (DT-283)

86-1. GENERAL.

a. The purpose of this test is to measure the output stability of the four-wire voice frequency channel over a specified period of time.

b. This test would not normally be a routine field test except for the 72-hour recording period specified in DCAC 310-70-57.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

86-2. SPECIFICATIONS.

a. As a design objective, the net loss variation of a long haul or of a tactical TDM/PCM reference voice bandwidth link shall not exceed ±0.25 dB over any 24 consecutive hours (short-term variation) and shall not exceed ±1.0 dB over any 30 consecutive days (long-term variation). MIL-STD-188-100)

b. A channel output level of the TD-1192 (AN/FCC-98) measured at the four-wire voice frequency output shall not deviate more than ±0.25 dB in any 24-hour period. A channel output level shall not deviate more than ±1 dB during any 30-day period. This measurement shall be made with the output channel terminated in 600 ohms ±10 percent and an input test tone level of 0 dBm0 at 1020±5 Hz. (CC-74047)

c. The AN/FRC-162 and VICOM 4000-2 system shall meet the D2 channel bank requirements of ±0.5 dB over a 3-month period.

d. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

86-3. TEST EQUIPMENT REQUIRED.

a. Transmission measuring set.

b. Voltmeter.

c. Frequency counter.

d. Stripchart recorder.

e. Logarithmic/linear amplifier.

f. 600-ohm precision termination (1 percent).

86-4. TEST PROCEDURES.

a. For this test, record the test tone for the period specified in paragraph 86-2, above. If the test is being performed as part of an onsite test and acceptance of new systems, the minimum recording period is 72 hours as specified in DCAC 310-70-57.

b. Perform the test at the circuit patch bay, the VFPB, or directly at the channel input and output. For most field test activities, it would be performed at the circuit patch bay.

c. Connect the test equipment as shown in figure 86-1. If using a programmable calculator, connect the test equipment as shown in figure 86-2. Allow approximately 30 minutes for warmup and stabilization.

d. At the transmit end, insert a 1020-Hz 0-dBm0 test tone into the channel to be used for the recording. If the test is being performed on an operational system, the test tone should be inserted at -15 dBm0 for long-term recordings.

NOTE: Verify the channel strapping to determine if it is strapped for 0 dBm or -16 dBm input and 0 dBm or +7 dBm output. For this test, the oscillator output must be extremely stable if the recorded data is to be compared to the specifications contained in paragraph 86-2.

e. At the receive end, measure the channel output level of the transmitted test tone and verify that the level is within ±0.25 dB of the transmitted level.

f. At the receive end, disconnect the multiplex channel output from point A of figure 86-1 and connect the transmission measuring set to the selected channel of the recorder through the AC-DC amplifier converter.

NOTE: This AC-DC amplifier converter may be part of the recorder.

g. Calibrate the recorder chart in 1-dB steps over a range of ±5 dB centered at the 1020-Hz reference tone established in subparagraphs d and e, above. Once the recorder channel has been calibrated, disconnect the transmission measuring set and connect the recorder to point A of figure 86-1 which may represent the circuit patch bay, VFPB, or equipment channel output.

h. Before starting the recorder, enter the following data on the recorder stripchart.

(1) Recording site.

(2) Distant station (terminal).

(3) Date, time (Zulu), and run number.

(4) Channel, digroup, and port.

(5) Calibration scale.

(6) Chart speed being used.

NOTE: The time constant network shown in figure 86-1 may not be required unless the test tone is extremely unstable.

i. Record the test tone for the period specified in paragraph 86-2, or as directed. During the recording, periodically monitor both the transmit and receive tone levels and frequencies to verify that the transmit tone level has not varied from the established reference.

j. At the transmit end, ensure that the receive end is notified of any changes in the input tone signal so that a suitable notation can be made on the stripchart at the receive end.

k. The test tone stability can be recorded in both directions of transmission simutaneously by following the above procedures for the opposite direction of transmission.

86-5. DATA RECORDING AND ANALYSIS. Use the data reduction techniques outlined in this paragraph to determine the measured performance as compared to the value specified in paragraph 86-2. Reduce all the recorded data and plot it as outlined in the following subparagraphs. Plot the measured performance parameter on figure 3-4(DD Form 2094) at the end of each run in order to obtain a real time measure of the performance.

a. Test Runs.

(1) Divide and number the paper stripchart recording in time intervals or runs. The duration of these runs should be approximately 5 to 15 minutes for short-term recordings (less than 72 hours) and 30 to 60 minutes for the long-term runs (more than 72 hours). The median (value) is defined as that level at which the curve (or recording) spends equal time above and below the referenced level.

(2) For each of the stripchart recorded signals, use a recording time constant which is small enough and a chart speed which is fast enough to delineate the signal so as to show the short-term variations. The short-term period is defined as being of short duration relative to the duration of a run.

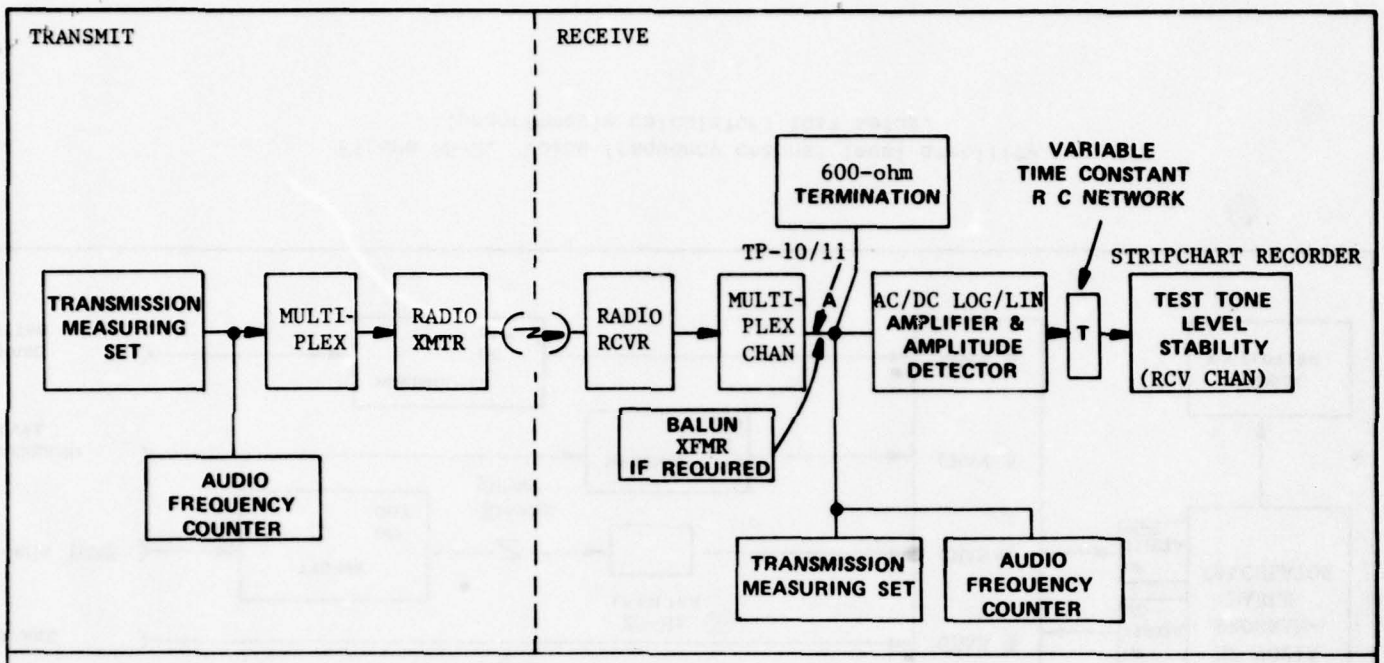
b. Medians of Chart Recordings.

(1) Determine the individual run-medians (with reasonably good accuracy) by means of a stretched string, parallel to the time axis, and located at the visually estimated median level. Note these median values on the chart, at the center of the run period, and on the particular curves to which they apply. As an alternate, use the scaling method of determining the individual run-median as follows: Select a visually estimated median level and add all of the time periods during which the recorded signal is above this level. If the total time is less than one-half of the run time, select a lower level and repeat the process. The true median is that level for which the total of the added time periods is equal to one-half of the run period.

(2) Determine the average power level and power level variations of the test tone stability from figure 86-3 (DCA Form (Test) T1-2) and record this data on figure 3-2 (DCA Form (Test) T1-8).

c. Remove all test equipment and restore the system to its normal configuration.

d. If the equipment/system fails to meet specified performance parameters, notify the responsible activity of required corrective actions.



NOTES:
1. Connect the 600-ohm termination as shown.
2. At the receive end, disconnect the multiplex from point A and connect the oscillator of the TMS. Set the oscillator for a 1020-Hz test tone at -15 dBm0 and center the pen on the recorder. Vary the output of the oscillator and calibrate the recorder in 1-dB steps from -20 dBm0 on the left side of the chart and to -10 dBm0 on the right-hand side. Use the procedures described in the recorder operating instructions for adjusting the pen placement.
3. After calibrating the recorder, reconnect the multiplex to point A. Have the transmit end send a -15 dBm0, 1020-Hz test tone. Measure the level and frequency of the test tone at the receive end at point A with the TMS in the bridging position. Verify that the recorder pen indicates the -15 dBm0 level.

Figure 86-1. Voice frequency channel level stability test setup.

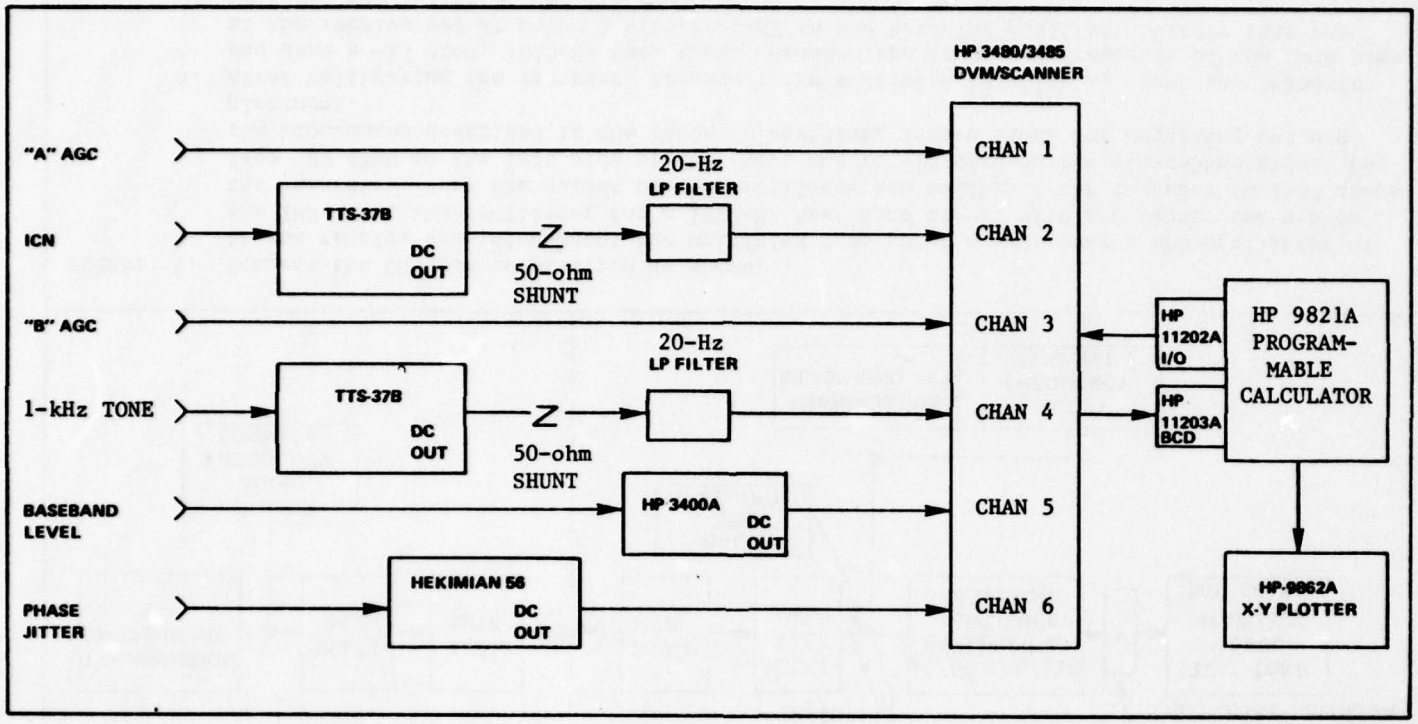


Figure 86-2. Voice frequency channel level stability (programmable calculator) test setup.

RADIO LINK RECORDED PARAMETERS
TEST TONE STABILITY

DATA SHEET T1-2

PAGE _____ OF _____ PAGES

DATE (day, mo., year)

V. CH. TEST POINTS (note any changes between runs on data sheet)

AT TRANS: TP-_____ AT REC: TP-_____

TEST ENGR. SIGNATURE

RADIO LINK STATIONS

STATION UNDER TEST

DISTANT STATION

DCS LINK NO.

TERMINAL RADIO EQUIPMENT

TEST TIME PERIOD

START Z STOP Z

RUN NO.	TEST RUN TIME Z			CHART SPEED MM MIN.	SG NO.	G NO.	V CH NO.	REC'D V.CH TEST TONE SIGNAL AV PWR LEVEL		TEST TONE STABILITY							
	START	STOP	DUR. OF RUN MIN.							NUMBER OF TEST TONE SIGNAL POWER LEVEL VARIATIONS AT THE INDICATED LEVELS, IN dB RELATIVE TO THE AVERAGE TEST TONE PWR. LEVEL.							
								dBm	dBm0	+1	-1	+2	-2	+3	-3	+5	-5

DCA FORM (TEST) T1-2 MAR 73

Figure 86-3. Test tone stability data sheet.

CHAPTER 87

VOICE FREQUENCY CHANNEL LONGITUDINAL BALANCE (DT-284)

87-1. GENERAL.

a. The purpose of this test is to determine the amount of imbalance existing on the voice frequency channels or other voice frequency transmission systems using balanced circuits.

b. This test may be performed on contractor EF&I systems to verify that they conform to the specifications stated in the contract or other applicable documents. It may also be used by installer or quality assurance personnel during onsite installation or test activities or as a diagnostic aid in resolving a particular problem as directed.

c. The method to be used for the test will depend on equipment availability or as directed by the team chief or onsite NCOIC. Different methods used for measuring longitudinal balance will produce different results; therefore, no attempt should be made to compare results unless the same procedures are used in reconstructing the test data.

d. Normally, speech or carrier signals are carried on a balanced transmission line consisting of two conductors at the same electrical potential above ground. Normal signal current flows in opposite directions in the two conductors, but unequal leakage impedances from the lines to ground, and electromagnetic or capacitive voltages induced in the line, produce longitudinal currents which create a voltage between the electrical center of the line and ground. This unbalance voltage causes interference with the desired signals in the line and adds to the idle noise of the system. To illustrate this, refer to figure 87-1 which shows a balanced circuit between the two line transformers. The signal voltage (E_g) causes a line current (I_{sig}) to flow through the two wires of the pair. The current flows in opposite directions on the two wires and passes through the line winding of the right transformer causing current to flow through the load Z_L. The generators in series with the two wires E_1 and E_2, represent an interference which is induced by an external source. The current I_1 and I_2 flow in the same direction. If they are equal, these currents will cancel in the balanced windings of the transformer so that no current flows in Z_L. The term metallic circuit currents is applied to the currents which flow in opposite directions in the wires of the pair, while those that flow in the same direction are called longitudinal currents. If there is any difference between the longitudinal currents in the line winding of the transformers, they will not completely cancel out causing unwanted currents to flow in the load Z_L. This unbalance may be due to a higher resistance in one wire than in the other such as a bad splice or other discontinuities. Or, if the two windings of the transformer which could represent a channel input, hybrid, or some other device in the circuit are not

perfectly balanced, the effects will be reflected at the load Z_L as unwanted currents. The degree of unbalance can be measured by the test described in subsequent paragraphs.

e. This procedure provides two methods for measuring the longitudinal balance of a voice frequency channel or circuit. The first method uses a longitudinal balance test set which is more effective and less time-consuming.

87-2. SPECIFICATIONS.

a. The electrical symmetry of the TD-1192 (AN/FCC-98) shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. (CCC-74047)

b. The longitudinal balance of the AN/FRC-162 and VICOM 4000-2 system shall be greater than 40 dB.

c. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

d. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

87-3. TEST EQUIPMENT REQUIRED.

a. Longitudinal balance test set or transmission measuring set.

b. Voltmeter.

c. Wave analyzer or frequency selective voltmeter.

d. Balanced/unbalanced center tapped transformer.

e. Isolation transformer.

f. Oscillator.

g. Precision resistors, as required.

87-4. TEST PROCEDURES.

a. Using the longitudinal balance test set method, proceed as follows:

(1) Complete the applicable blocks of figure 87-2 (DD Form 2109). Modify the data sheet to read 1st level multiplexer and 2d level multiplexer instead of supergroup and group. Change the frequencies to those indicated in the procedures.

(2) The IEEE method designates the longitudinal balance by the formula $20 \log_{10} \frac{V_s}{V_m}$, where V_s is the disturbing longitudingal voltage and V_m is the resulting metallic voltage. Therefore, V_s corresponds to V_1 and V_m to V_2 on figure 87-2 (DD Form 2109).

(3) Calibrate the test set at both ends of the circuit (driving and terminating) according to the equipment instruction manual supplied with the test set.

(4) Since V_s (V_1) will not appear directly across the pairs, a V_s of +10 dBm0 is used instead of the normal -10 dBm0 test tone level in order to exhibit a higher level of V_m (V_2) across the line.

(5) Connect the test equipment as shown in figure 87-3 for measuring the longitudinal balance of the voice channel inputs. Adjust the test set internal oscillator to 1020 Hz and insert the +10 dBm0 test tone level into the channel under test. This would normally be at the circuit patch bay; however, it may be at the VFPB or at the channel if directed otherwise.

(6) Record the source voltage V_s (V_1), the metallic voltage V_m (V_2), the ratio $\frac{V_s}{V_m}$ and the calculated longitudinal balance from

$$20 \log_{10} \frac{V_s}{V_m} \text{ or } 20 \log_{10} \frac{V_1}{V_2}.$$

(7) Repeat the above procedure for input (driving) frequencies of 610 and 1510 Hz.

(8) To measure the balance of the terminating circuit, send a 1020 Hz test signal from the receive end to the transmit end. The longitudinal test set normally contains a switch marked shunt series which is used in measuring the balance of the terminating circuits. With the switch in the series position, the effect of series unbalance is emphasized. If the switch is thrown to the shunt position and the balance remains unchanged, this indicates that series unbalance may not be the primary cause of unbalance. If there is a change, it indicates that series unbalance is, to some extent, dominant. Enter the data for both shunt and series values on the data sheet.

(9) Repeat the above procedures for frequencies of 610 and 1020 Hz. Record the results on the data sheet.

(10) If a requirement exists to test channels or circuits equipped with E&M signaling, operate the make-busy switches to the make-busy position. Also, apply a -48 VDC and ground to the E&M leads of the channel under test.

b. For the conventional method, proceed as follows:

(1) Connect the test equipment as shown in figure 87-4. This arrangement is used for input circuits. If the test is to be performed on a radio link

basis or on a cable pair, terminate the receive end in its characteristic impedance.

(a) In the circuit shown, adjust the oscillator for a 1020-Hz test frequency and at the proper power level for the circuit or equipment to be tested. Normally on DCS systems a -10 dBm is used as the standard test tone level. Initially set the oscillator to 1020 Hz connected through transformer A across the center tapped resistors R_1 and R_2 into the circuit or equipment under test.

(b) Connect the frequency selective voltmeter (bridging mode) to measure the voltage across R_L (R_3 on fig. 87-4), and tune the frequency selective voltmeter to the 1020-Hz signal using the most narrow bandwidth position. The frequency selective voltmeter or wave analyzer is necessary because of the wide bandwidth of most voltmeters which allows them to pickup signals other than the low level imbalance signal. As a precautionary measure, disconnect the oscillator. Measure the voltage across R_3 to determine if other signals, including crosstalk, are present in sufficient magnitude to influence the unbalance voltage (V_2) during the test.

(c) Reconnect the oscillator to the transformer and measure the voltage (V_2) across resistor R_3. Record this value on figure 87-2 (DD Form 2109). Note and record the V_1 voltage measured across the line by the voltmeter.

(d) Calculate the longitudinal balance of the input circuit using the following formula.

$$\text{Longitudinal balance} = 20 \log_{10} \frac{V_1}{V_2}$$

Since the voltage V_1 is measured across the line with a normal impedance (R) of 600 ohms, while the voltage V_2 is measured across R_3 having an impedance of 150 ohms, the above definition and measurement is in relative terms and shoul not be considered as an absolute power ratio measurement.

(e) Repeat paragraph 87-4b(1) for the remaining frequencies contained on the data sheet or as directed.

(f) For an alternate test setup, see figure 87-5.

(2) To measure the output (receiving) longitudinal balance, connect the test equipment as shown in figure 87-6, with the output channel or circuit terminated by resistors R_1 and R_2 connected in series as shown. The resistors used should be of the precision type having an accuracy of ±0.25 percent or better.

(a) Adjust the oscillator output frequency to 1020 Hz at a power level of -10 dBm0. In this case the test signal is inserted backwards; that is, into the output of the channel or device being tested with the receive end terminated.

(b) Repeat paragraphs 87-4b(1) (a) through (e) for the output (receiving) as outlined above for the input measurements.

(c) Record the measured test results on the data sheet.

c. Typical test setups for measuring the longitudinal balance of an E&M converter at a telephone exchange are shown in figures 87-7 and 87-8. Basically, the measurement techniques are the same as for a channel or circuit except a DC power source is used to control the E&M converter.

d. Remove all test equipment and restore the equipment to its normal configuration.

87-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of figure 87-2 (DD Form 2109) and verify that the test results are within specified limits. Plot the curves on figure 3-4 (DD Form 2094). Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

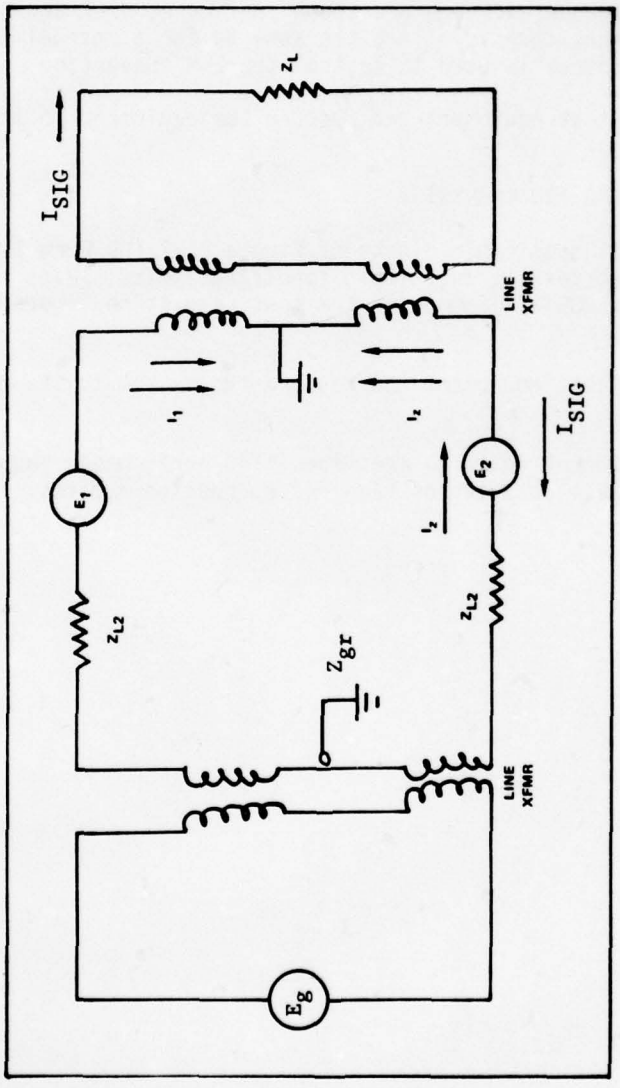


Figure 87-1. Balanced circuit between two line transformers.

VOICE CHANNEL LONGITUDINAL BALANCE					PAGE ____ OF ____ PAGES DATE	
DCS LINK NO.	STATION UNDER TEST		DISTANT STATION		ENGR. INIT.	TECHN. INIT.
	TEST POINTS		REP. TEST TONE SIGNAL POWER		TEST SIG. PWR. REL. TO REP. TEST TONE	ABSOLUTE POWER OF TEST SIGNAL
TRANSMIT	TP ____		____ dBm		____ dBm0	____ dBm
RECEIVE	TP ____		____ dBm		____ dBm0	____ dBm

FREQUENCY			600 Hz				1000 Hz				2400 Hz			
SG	GP	CH	LINE VOLTS V1	UNBAL VOLTS V2	$\frac{V1}{V2}$	LONG. BAL $20 \log \frac{V1}{V2}$ dB	LINE VOLTS V1	UNBAL VOLTS V1	$\frac{V1}{V2}$	LONG. BAL $20 \log \frac{V1}{V2}$ dB	LINE VOLTS V1	UNBAL VOLTS V2	$\frac{V1}{V2}$	LONG. BAL $20 \log \frac{V1}{V2}$ dB

DD, FORM 1 SEP 77 2109

Figure 87-2. Voice channel longitudinal balance data sheet.

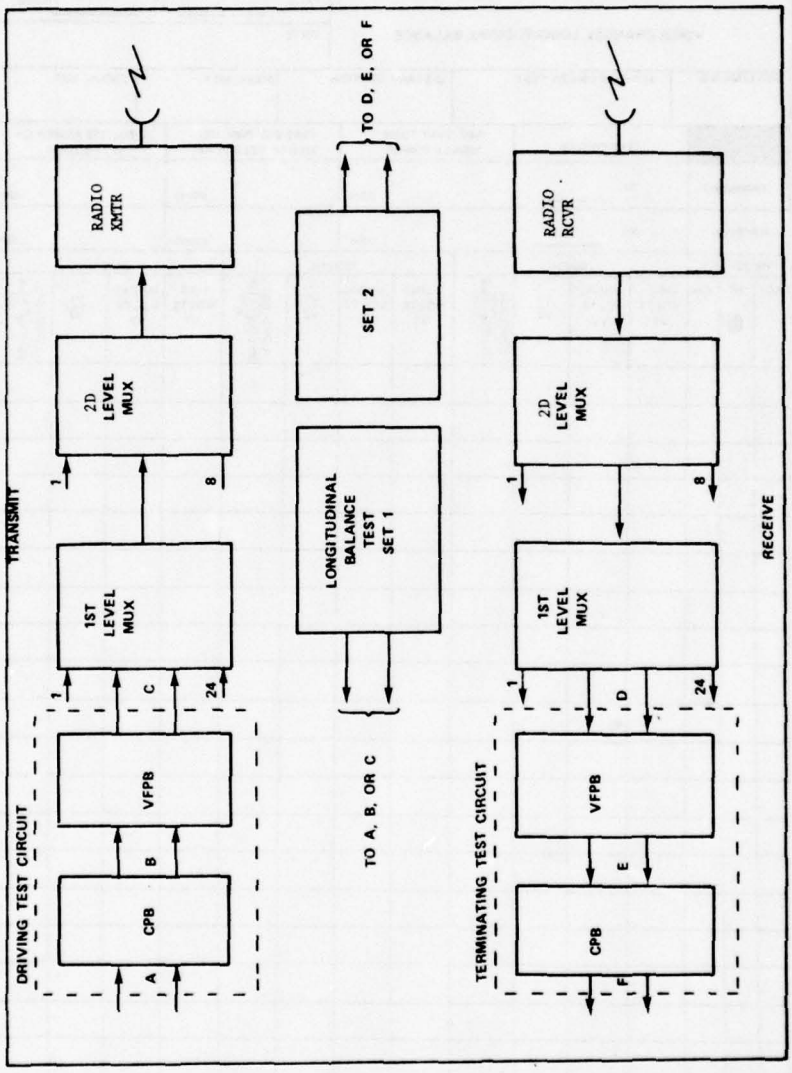


Figure 87-3. Voice frequency channel longitudinal balance (test set) test setup.

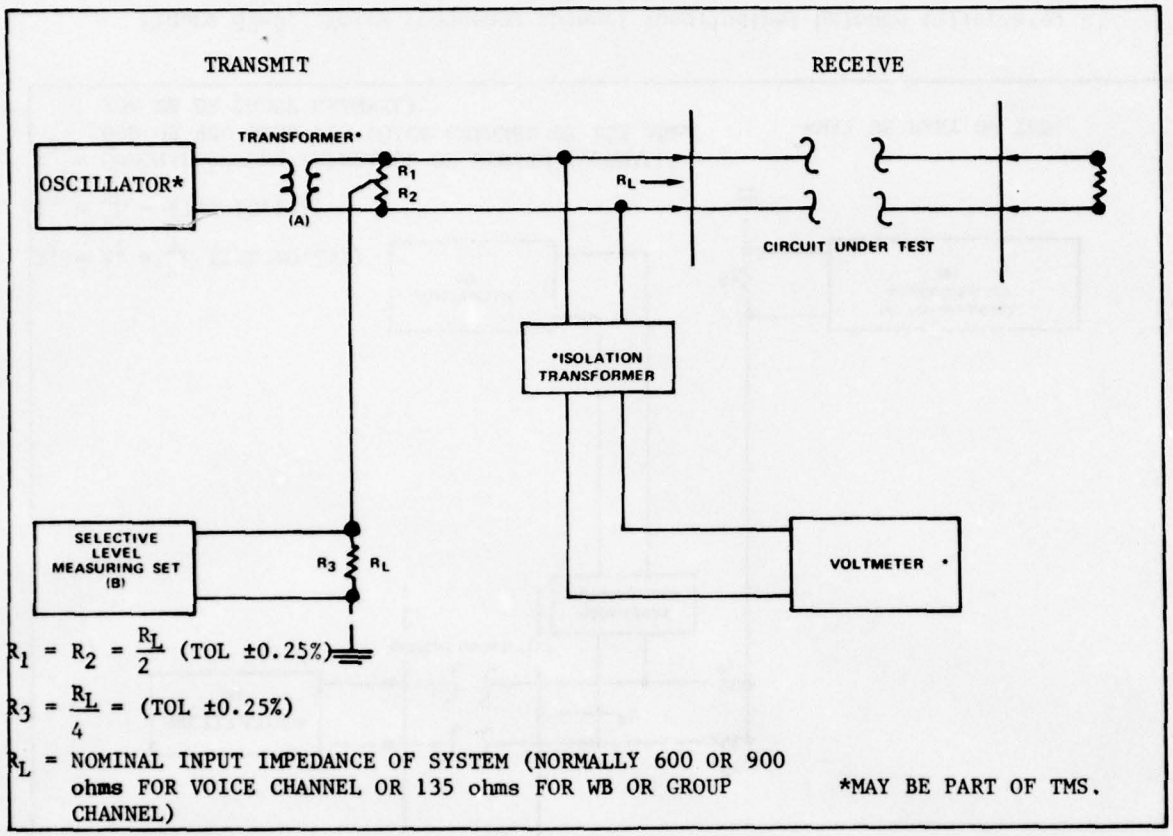


Figure 87-4. Voice frequency channel longitudinal balance (conventional) test setup.

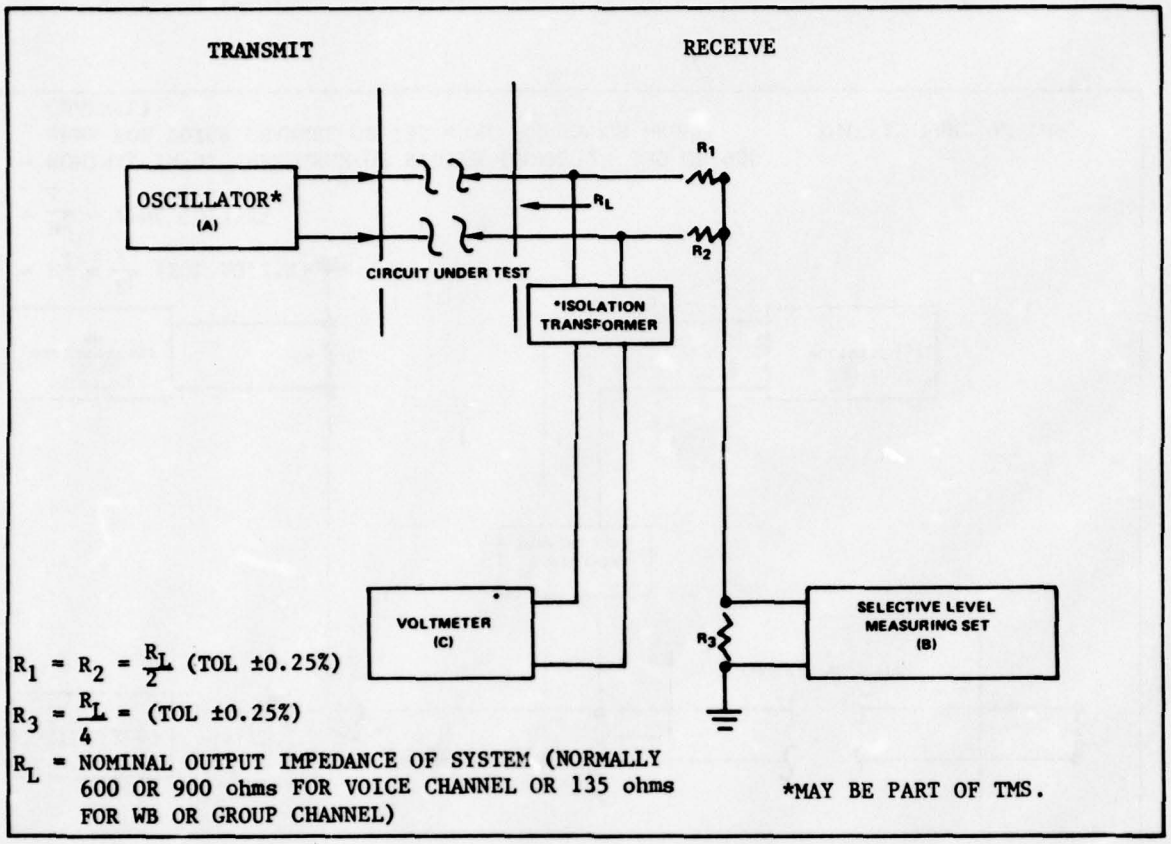


Figure 87-5. Voice frequency channel longitudinal balance (alternate) test setup.

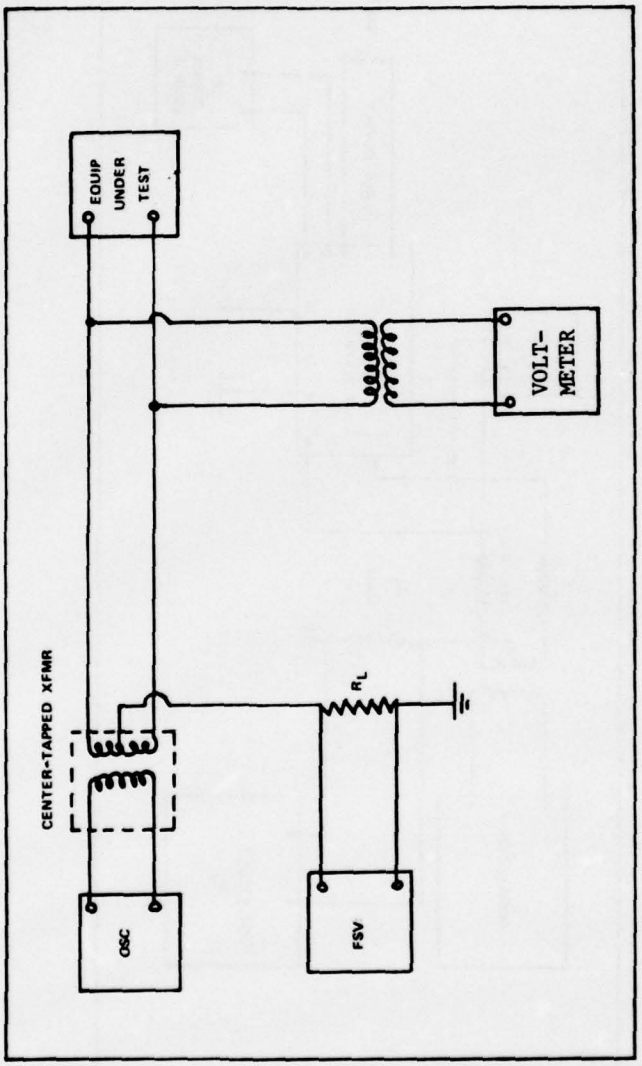


Figure 87-6. Voice frequency channel output (receiving) longitudinal balance test setup.

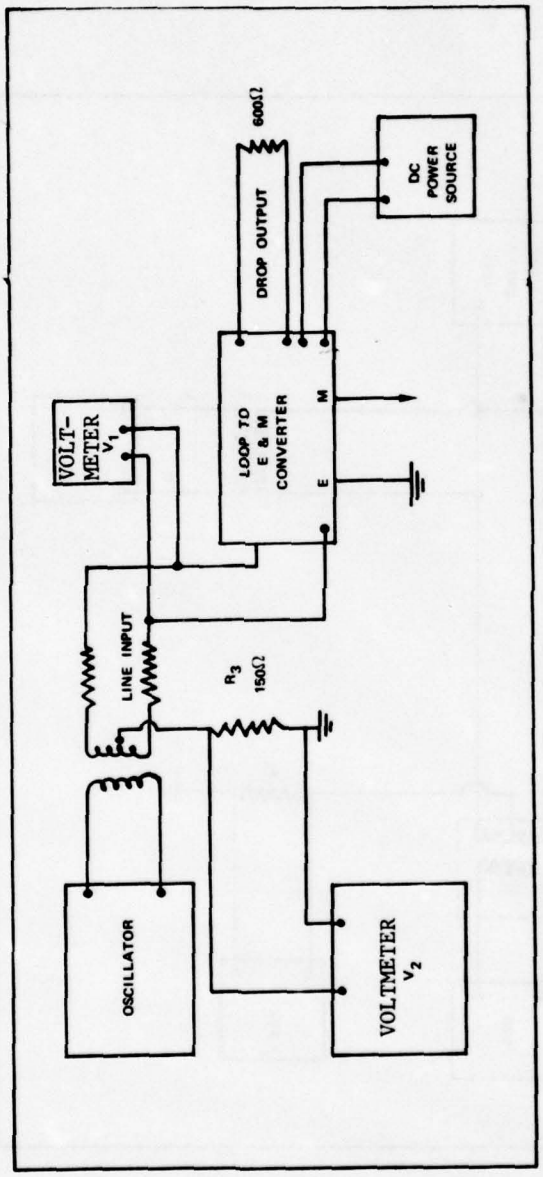


Figure 87-7. Voice frequency channel longitudinal balance (balanced transformer network) test setup.

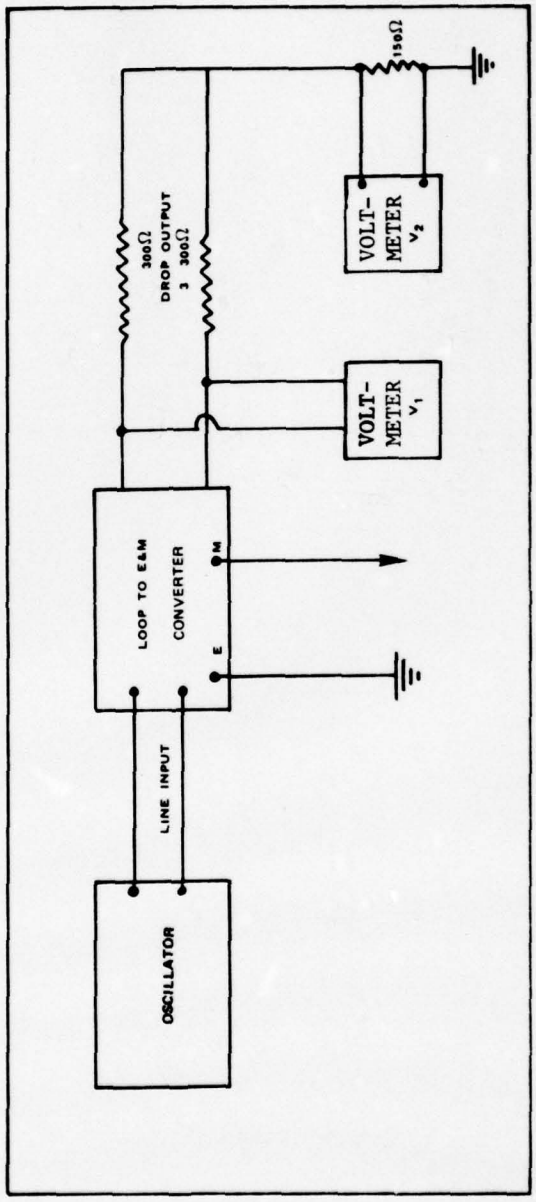


Figure 87-8. Voice frequency channel longitudinal balance (resistive network) test setup.

CHAPTER 88

VOICE FREQUENCY CHANNEL BIT ERROR RATE (DT-285)

88-1. GENERAL.

a. The purpose of this test is to measure the high speed data transfer capabilities of a nominal voice frequency channel.

b. Data transmission is usually accomplished by converting the binary DC signal into a quasi-analog form for transmission over channels which are not capable of transmitting signals in DC form. Characteristics of a number of conversion devices (MODEMS) are standarized in order to accommodate the variety of data to be transmitted over the different types of available transmission media. The quasi-analog signal does not have to be in binary form since multi-level (M-Ary) modulation schemes are also being used for converting the binary DC signal into a quasi-analog form.

c. The data signaling rate is usually expresed in b/s and the modulation rates as baud (Bd). Data signaling rates (b/s) and modulation rates (Bd) are the same if, and only if, all pulses are the same length, all pulses occupy the complete unit interval, and binary (rather than M-Ary) signaling is used.

d. A MODEM generates a quasi-analog signal suitable for the analog voice channel input. If the quasi-analog signals are binary in a synchronous system, the nominal time structure of the DC signal is not affected by the MODEM, and the rate of the quasi-analog signal may be expressed in either Bd or b/s. In more sophisticated systems, this is generally not true.

e. This test may be performed at any baud rate determined to be applicable to the MODEM and/or transmission media being tested. For the purpose of illustration, 2400 b/s is used in the procedure described in subsequent paragraphs.

f. This test may be performed during acceptance testing of contractor EF&I systems to ensure that they conform to the contract specifications or other applicable documents. It may also be used by installer or quality assurance personnel during onsite test and acceptance as directed. The number of channels or circuits to be tested will normally be specified; however, an adequate number of measurements for those channels carrying low speed data should be made across the baseband spectrum to provide a high degree of confidence that the system's performance meets specifications.

g. This test may be performed in conjunction with a recording of other time varying parameters such as RSL and S/Nq. It may also be performed on a spot basis; however, to compare the measured results to the DCA standard, the results must be recorded for a specified period of time.

88-2. SPECIFICATIONS.

a. The following criteria applies to the multiplex equipment. (DCAC 300-175-9, app C)

(1) The average BER performance for 50 through 9600 b/s derived from dedicated voice frequency circuits on an end-to-end basis over the government operated and maintained portion of the DCS shall equal or exceed $1x10^{5}$ over any 10^{6} bit interval, 99 percent of the time.

(2) The average BER (1.544 mb/s) measured over the worst 30-minute interval minus the maximum allowable (ratio of errored bits to total transmitted bits):

$0.54x10^{-10}$ L_1 L_1 = Length in km
$1.45x10^{-10}$ L_2 L_2 = Length in miles

For circuits that are not to be extended (direct user-to-user 1.544 mb/s) the BER requirement is $1x10^{-7}$ and the availability is 99 percent.

b. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

88-3. TEST EQUIPMENT REQUIRED.

a. Data error rate test set.

b. Digital printer.

c. Transmission measuring set.

d. Stripchart recorder.

e. Balanced/unbalanced transformer.

f. Data MODEM.

88-4. TEST PROCEDURES. The average BER per run is defined as the number of bit errors measured during the run interval divided by the total number of bits transmitted during the run. The average BER is related to the median RSL if performed during, and in conjection with, an RSL recording. In order to obtain a range of RSL's and consequently a range of average BER's and hence a better plot of RSL versus BER, an artificial variation of the RSL can be produced by varying the effective received power by inserting attenuators at the receiver input terminals. Generally, the average BER measurements are made between the transmit and the receive circuit patch bays. If the average BER is excessive, additional measurements should be made between intermediate points in order to isolate the source of the excessive errors. This test should be performed after all equipment maintenance, installation, and adjustments have been made.

a. Complete the top portion of figure 88-1 (DD Form 2115).

b. Connect the test equipment as shown in figure 88-2 and allow approximately 30 minutes for warmup and stabilization.

(1) At the transmit end, adjust the transmit oscillator for a 1020-Hz test tone at -10 dBm0 as read on the voltmeter. Insert the tone into the channel at the circuit patch bay to be used for measuring BER. Use a 0-dBm0 tone on non-operational systems.

(2) At the receive end, connect the voltmeter to the circuit patch bay of the channel selected for the BER measurement. The voltmeter (in the terminated mode) should read -10 dBm0 ±1 dB. If the levels are not within the specified tolerance, select another channel or adjust the channel output to the established tolerance. Once the levels have been verified as correct, remove the test equipment at both the transmit and receive ends.

c. Connect the test equipment as shown in figure 88-3 and allow approximately 30 minutes for warmup and stabilization.

(1) At the transmit end, adjust the MODEM voice frequency output level for -10 dBm0 and connect it to the channel selected for testing at the circuit patch bay. The oscillator shown in figure 88-3 may be part of the MODEM which provides timing for the data test set. If only one BER test set and data MODEM are available, make the measurement on a looped basis. In such cases, loop the tested channel at the receive end of the circuit and the measured BER at the transmit end.

(2) At the receive end, connect the data MODEM to the channel selected for testing at the circuit patch bay. The received MODEM level should read -13 dBm0 ±1 dB on the voltmeter (bridging position).

(3) At the transmit and receive ends, set the pattern generator and the data MODEM to operate at the selected bit rate or as directed. Ensure that both the pattern generator and the data MODEM are set at the beginning of the test pattern sequence before starting the test. This is accomplished by momentarily pressing the clear-to-send switch on the data test set.

(4) If the data test set includes a provision for measuring events over a preset time period, set the transmit counter to correspond to the interval specified by the team chief or the applicable specification. If not so equipped, divide the recorder printout into specified time intervals. This will represent the run period.

(5) At the transmit end, activate the send data switch on the data test set, and at the receive end, observe the MODEM and data test set for proper operation. If desired, have the transmit end manually introduce data errors, block errors, and loss of synchronization while at the rceive end, observe that the sequence is recorded on the printout. Clear the sequence and resume sending data pattern for the chosen time interval.

NOTE: The MODEM may be part of the multiplex on some systems.

d. If other time varying factors are being recorded, such as RSL, choose the time interval that corresponds to the run interval of the recorded RSL. As an example, if the run interval for data transmission is 30 minutes, the same 30 minutes on the RSL should be used to correlate the BER to the RSL. If the RSL is not being recorded, the link is stable, and a calibrated AGC versus RSL curve is available, the RSL should be obtained from the AGC curve for the run interval.

e. The preferred method is to record the RSL and S/Nq time correlated with the BER measurement. This aids in the analysis process of determining the the cause for errors during transmission. If these parameters are recorded:

(1) For each run, record the number of bits transmitted and number of errors, and calculate the BER. Also record the total number of bit errors on figure 88-1 (DD Form 2115) and the stripchart recording of the RSL.

(2) In analyzing the BER, use figure 29-3 (DD Form 2098), entering the number of times carrier loss, clock slip, block error, etc., are encountered through-out the recording period. This information can be obtained from the digital printer record.

(3) Plot the run average BER versus the (corresponding) run-median RSL on figure 29-4 (DD Form 2099).

(4) Complete figure 29-3 (DD Form 2098) from the data entered on figure 88-1 (DD Form 2115).

(5) To obtain the long-term cumulative distribution of the average BER, plot the data from the right-hand column of figure 29-3 (DD Form 2098) on figure 29-4 (DD Form 2099).

f. For measurements of additional channels/circuits, repeat the above test procedures. For time correlated BER versus RSL, use only one channel.

88-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable data elements of the data sheets and examine the BER versus RSL plot to ensure that the measured results are within specifications. Modify the data sheets as necessary.

b. Summarize the test results on figure 3-7 (DD Form 2091).

c. Remove all test equipment and restore the system to its normal configuration.

d. If the channels fail to meet the specified performance requirements, notify the responsible activity of required corrective actions.

DATA ERROR RATE

PAGE _____ OF _____ PAGES

DATE

DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENCR. INIT.	TECHN. INIT.

TEST POINTS: TRANSMIT TP _____ RECEIVE TP _____ MSG. SIG. LDG. LVL.: _____ dBm; _____ dBm0

RUN NO.	RUN TIME PERIOD START	RUN TIME PERIOD STOP	DUR MIN.	CHANNEL POS. S G	G	V CH	TRANSMIT SIG. LEVEL dBm	TRANSMIT SIG. LEVEL dBm0	RECEIVED SIG. LEVEL dBm	RECEIVED SIG. LEVEL dBm0	BIT RATE, B/S	NO. OF BITS TRANS.	NO. OF ERRORS	AVG. BIT ERROR RATE %	MEDIAN BB SIG. LOADING dBm0	MEDIAN RSL dBm

DD FORM 1 SEP 77 2115

CCP 702-11

Figure 88-1. Data error rate data sheet.

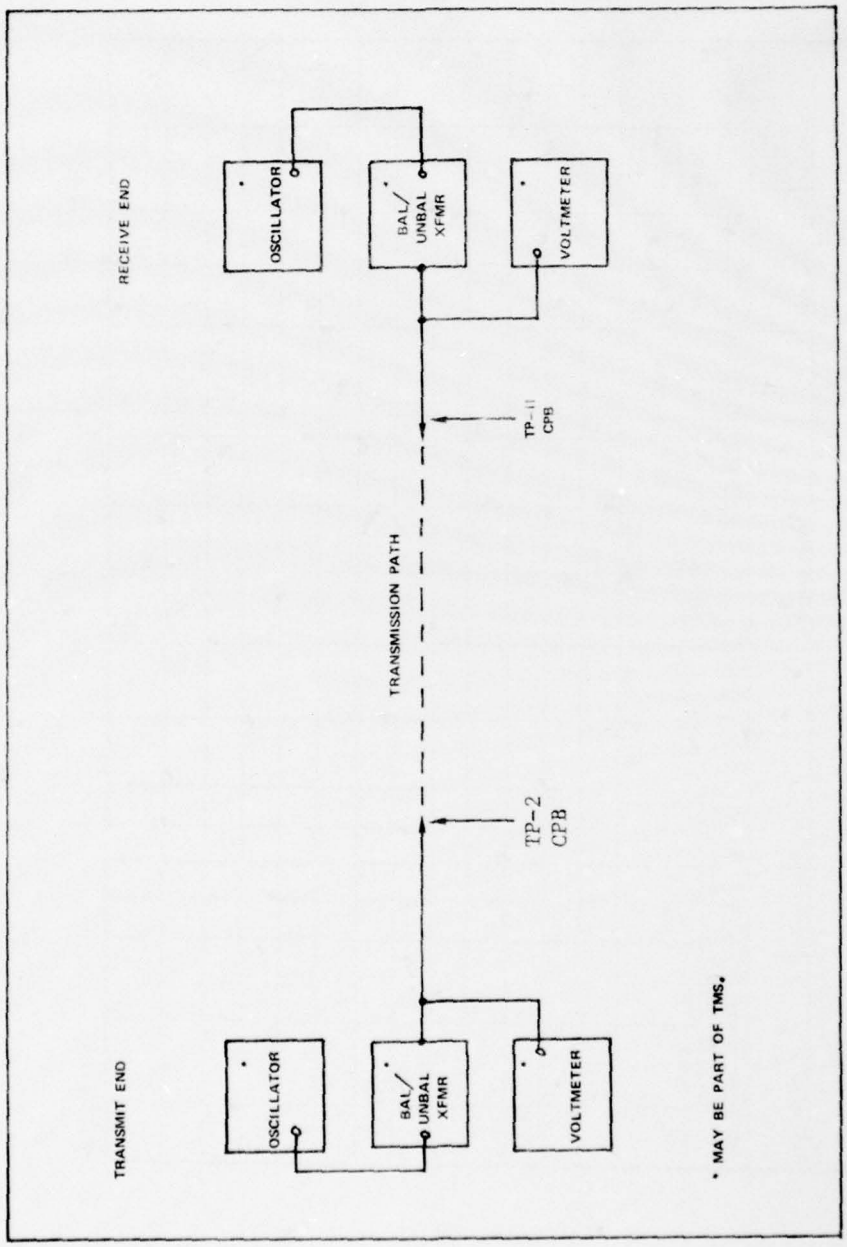


Figure 88-2. Voice frequency channel BER (level verification) test setup.

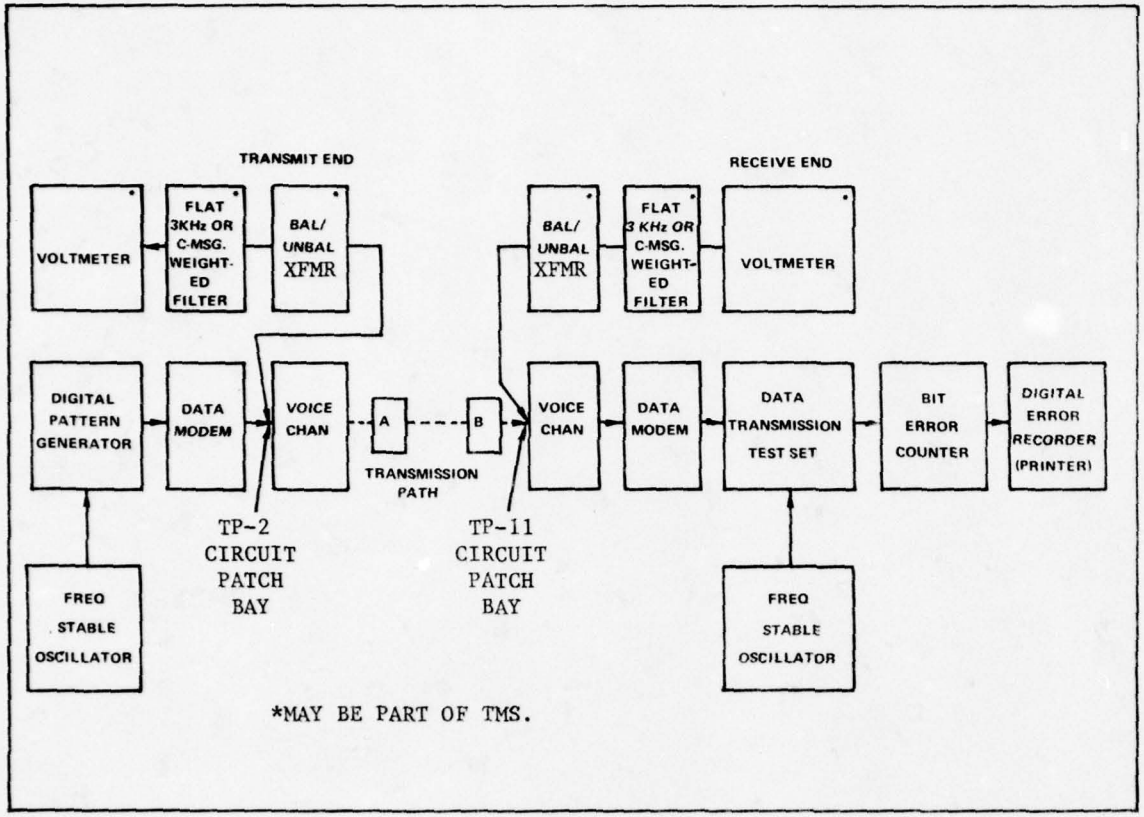


Figure 88-3. Voice frequency channel BER (measurement) test setup.

CHAPTER 89

TD-1192 (AN/FCC-98) BIT ERROR RATE AND BIT COUNT INTEGRITY (DT-286)

89-1. GENERAL.

a. The purpose of this test is to determine the BER and BCI of the TD-1192 (AN/FCC-98) digital multiplex equipment.

b. The TD-1192 1st level multiplex maximum digital channel capacity is based on the channel version in use as shown in table 89-1. These data rates are obtained by substitution of the data interleaving cards with the voice frequency channel cards. The digital data cards will insert the digital data directly into the output bit stream and extract the digital data from the input bit stream. The digital data cards will insert into and extract the digital data from the channel time slot or slots that the replaced voice channel cards occupied. Insertion of a digital data card will inhibit E&M signaling for the replaced voice frequency channels.

c. This test may be performed at the station data patch panel if so equipped, at the channel input/output terminals of the equipment, or at any other accessible test point. If testing to verify that the initial equipment delivery meets the requirements of paragraph 89-2, below, it should be performed directly at the channel input/output terminals.

d. This test may be performed on contractor EF&I systems to ensure that they conform to specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

89-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) With the multiplex terminal in frame synchronization and receiving data with a BER of zero, the BER at any data channel output shall not exceed $1x10^{-7}$.

(2) The data channel tandeming performance for 56, 64, 128, 256, and 512 kb/s of data transversing five consecutive multiplex and demultiplex functions shall not exhibit a BER at the data channel output greater than $1x10^{-7}$ after the multiplex terminals have achieved frame synchronization.

(3) With a stable 50-kb/s asynchronous (±250 parts per million) data input to the first of three tandemed multiplex terminals, the asynchronous 50-kb/s data shall not exhibit a BER at the data channel output greater than $1x10^{-7}$ after the multiplex terminals have achieved synchronization. With the same stable input data, the 50-kb/s data shall not experience any loss of BCI.

(4) With the multiplex terminal maintaining BCI multiplexer output to demultiplexer input, in a BER invironment of $1x10^{-3}$ randomly distributed, the mean time to loss of BCI at any 56-, 64-, 128-, 256-, and 512-kb/s channel output shall be at least 24 hours.

(5) When the multiplex terminal is in frame synchronization, the mean time between loss of BCI at any 50-kb/s output due to stuff/destuff signal errors shall not be less than 24 hours in an error environment of $1xi0^{-3}$ randomly distributed.

b. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

89-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Oscilloscope.

c. Digital recorder or stripchart recorder.

d. Frequency counter.

e. Impedance matching networks, as required.

89-4. TEST PROCEDURES. The BER performance of the digital radios, if used during this test, are assumed to have met the required equipment specifications during DT-226. If this test is used for link testing and the radio performance has not been verified, DT-226 will precede this test.

a. Connect the test equipment as shown in figure 89-1 and allow approximately 30 minutes for warmup and stabilization. If testing the TD-1192 (AN/FCC-98) to the requirements contained in paragraph 89-2, the 1st level multiplex shown as N-terminals in figure 89-1, represents from one to five multiplex and demultiplex terminals.

b. Verify that the multirate data modules are installed, the E&M leads are inhibited for those channels that are to be used for data transmission, and that equipment and channel strapping options have been completed using tables 89-2 through 89-8.

NOTE: If testing directly at the multiplex terminal channel input/output, the data channel card should be placed on an extender board and connected as shown in figure 89-2.

c. Connect the bipolar/NRZ data output of the last tandem multiplex to the demultiplex input as shown in figure 89-1. If the transmission media is unstable, connect the BER test set to the 1.544 mb/s input of the last tandem unit as shown in figure 89-1.

d. At the transmit terminal, set up the BER test set pattern generator in accordance with the manufacturer's operating instructions supplied with the instrument. Set the bit rate select switch and format to correspond to the data channel bit rate. Refer to table 89-1 for the data channel input/output rates at which the TD-1192 (AN/FCC-98) may be configured to operate.

NOTE: If the BER test set input/output impedances and balanced/unbalanced output conditions do not correspond to the test point being used, use an appropriate interface device.

e. At the transmit and receive ends, measure the input and output levels of the data channel under test and record these levels on figure 89-3 (USACC Form 666-R). If the levels are not within the equipment interface tolerances, adjust them to the correct level before proceeding with the tests. At both terminals, measure and record on the data sheet the MBS input and output levels.

f. At both terminals, verify that the terminals have synchronized and alarm lamps are extinguished.

g. At the transmit end, set the BER test set for a 20-kb/s (10101010) pattern or some other pseudo-random word sequence and transmit data into the channel under test for approximately 15 minutes. If testing to verify the BCI of paragraph 89-2, above, perform the test for 24 hours at a BER equivalent of $1x10^3$. For general field testing, 15 minutes will be adequate for both the BCI and BER equipment verification.

h. At the receive end, connect the bit error detector to the data channel output as shown in figure 89-1 or 89-2. Set the frequency counter time base to the 10^8 position, input to ±DC at a level of 1 volt, and delay fully counterclockwise. With the 10^8 time base setting, each time period equals approximately 65 seconds. Connect the output of the frequency counter to the digital printer or stripchart recorder as shown in figure 89-1 or 89-2 to provide for unattended operation.

i. At a convenient time, start the counter and record the individual run BCI on figure 89-3 (USACC Form 666-R). Also record the number of bit errors for each time period. The average BER and BCI errors per run is defined as the number of errors measured during the run interval divided by the total number of bits transmitted during the run interval. For each run, record the bit rate, block size (if applicable), blocks transmitted, bit errors, and BCI errors.

j. If a digital printer or stripchart is used, record the number of bits transmitted, number of errors, and average BER for 15 minutes.

k. Repeat the above procedures for the 50-, 56-, 64-, 128-, 156-, and 512-kb/s data channels.

l. Reverse the direction of transmission and repeat the above procedures for the opposite direction of transmission. If equipment and personnel are available, perform the test in both directions simultaneously.

89-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of figure 89-3 (USACC Form 666-R) and determine if the channels are within specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If any of the data channels fail to meet the BER or BCI requirements, notify the responsible activity of required corrective actions.

Table 89-1. Maximum Number of Data Channels

DATA INTERLEAVING CHANNELS (kb/s)	3/6/12/24-CHANNEL VERSION CHANNEL MODE				24-CHANNEL VERSION DATA FORMAT	
	3	6	12	24	BIPOLAR	NRZ
0-20 (A)	3	6	12	12	12	12
50 (A)	3	6	12	12	12	12
56 (S)	3	6	12	12	12	12
64 (S)	--	--	--	12	12	12
128 (S)	--	--	--	6	6	6
256 (S)	--	--	--	3	3	3
512 (S)	--	--	--	1	1	1
A = asynchronous S = synchronous						

Table 89-2. Channel Operational Switch Settings

OPERATING MODE CHANNELS*	RCV INTFC UNIT				XMT INTFC UNIT	RCV INPUT UNIT
	S1	S2	S3	S4	S1	S1
24	0	4	6	0	7	3
12	0	4	3	1	6	6
6	0	6	5	2	5	5
3	0	7	6	3	4	4

* If the switches are improperly set, fault lamps on the power alarm panel and receive interface module will light and frame loss lamp on receive interface module will light.

Table 89-3. Outgoing Group Alarm Strapping

OPTION	MODE	XMT INTFC UNIT
B2 = 0 only	Analog	E8 to E9
B2 = 0 plus 00001111	Digital	E7 to E9

Table 89-4. Bit Stream (24-Channel Digital Timing Generator (DTG)) Strapping

FORMAT*	RCV INPUT UNIT	XMT OUTPUT UNIT
NRZ	1 to 3 2 to 5 7 to 9	2 to 3 5 to 6 5 to 6
BIPOLAR	1 to 4 2 to 6 7 to 8	1 to 3 -- 4 to 6

*If switches are improperly set, a fault alarm lamp will light on the power alarm panel.

Table 89-5. Zero-Suppression (24-Channel DTG) Strapping

OPTION	XMT INTFC UNIT
Disable Enable	E1 to E2 E2 to E3

Table 89-6. 50-kb/s Data Module Strapping

OPTION INPUT/OUTPUT	STRAP	
	S1	S2
Balanced (78Ω) Unbalanced (50Ω)	Closed - on Open - off	Open - off Closed - on

Table 89-7. Multirate Data Module Clock Source Strapping

OPTION	STRAP
Internal External	S2-7 Closed S2-7 Open

Table 89-8. Multirate Data Module Switch Options

RATE kb/s	CLOCK	CHANNEL USE	SWITCH POSITION											
			S1-1	S1-2	S1-3	S1-4	S1-5	S2-1	S2-2	S2-3	S2-4	S2-5	S2-7	S2-8
56	Intl	--	On	Off	Off	Off	On	Off	Off	Off	On	Off	On	On
56	Ext	--	On	Off	Off	Off	On	Off	Off	Off	On	Off	Off	On
64	Intl	--	On	Off	Off	Off	On	On	On	On	On	Off	On	On
64	Ext	--	On	Off	Off	Off	On	On	On	On	On	Off	Off	On
128	Intl	Alternate	Off	On	Off	Off	On	On	Off	On	On	On	On	Off
128	Ext	Alternate	Off	On	Off	Off	On	On	Off	On	On	On	Off	Off
128	Intl	Adjacent	On	Off	Off	Off	Off	On	Off	On	On	On	On	On
128	Ext	Adjacent	On	Off	Off	Off	Off	On	Off	On	On	On	Off	On
256	Intl	Alternate	Off	Off	On	Off	On	On	On	Off	On	On	On	Off
256	Ext	Alternate	Off	Off	On	Off	On	On	On	Off	On	On	Off	Off
256	Intl	Adjacent	Off	On	Off	Off	Off	On	On	Off	On	On	On	On
256	Ext	Adjacent	Off	On	Off	Off	Off	On	On	Off	On	On	Off	On
512	Intl	Alternate	Off	Off	Off	On	On	On	Off	Off	Off	Off	On	Off
512	Ext	Alternate	Off	Off	Off	On	On	On	Off	Off	Off	Off	Off	Off
512	Intl	Adjacent	Off	Off	On	Off	Off	On	Off	Off	Off	Off	On	On
512	Ext	Adjacent	Off	Off	On	Off	Off	On	Off	Off	Off	Off	Off	On

CCP 702-11

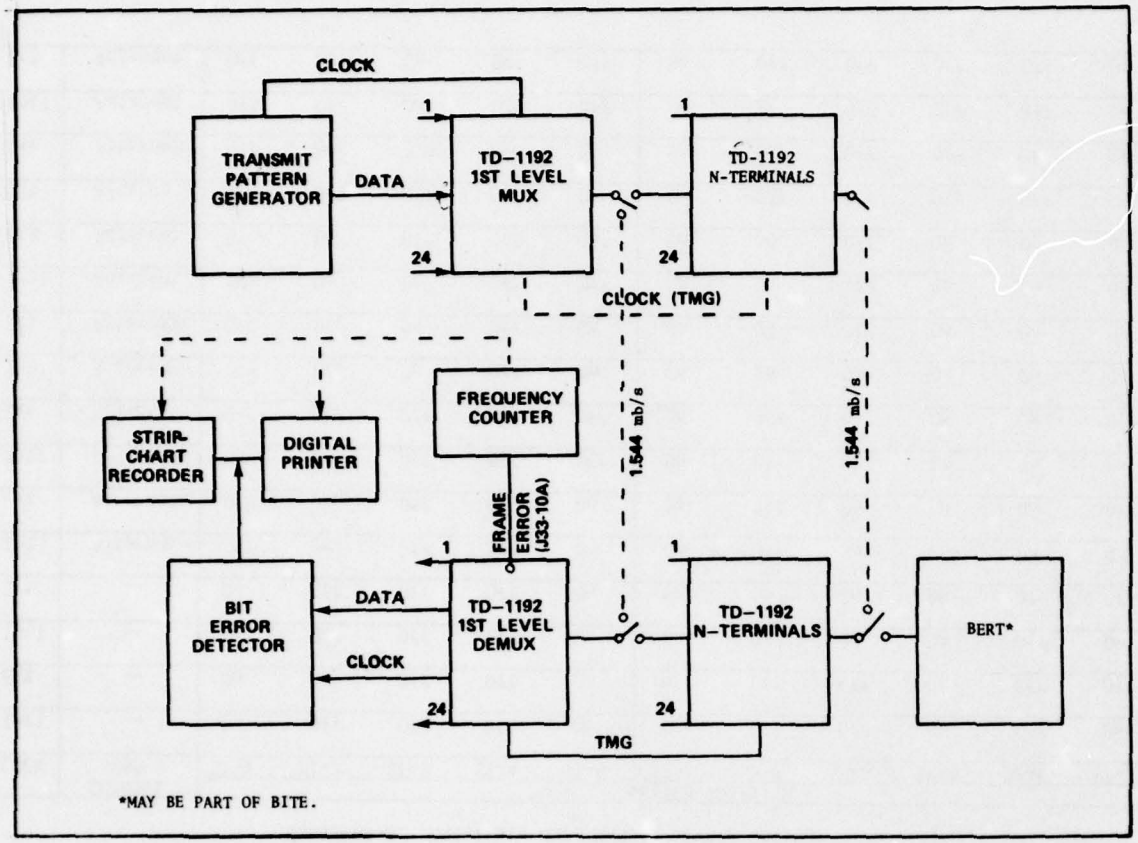


Figure 89-1. TD-1192 (AN/FCC-98) BER and BCI test setup.

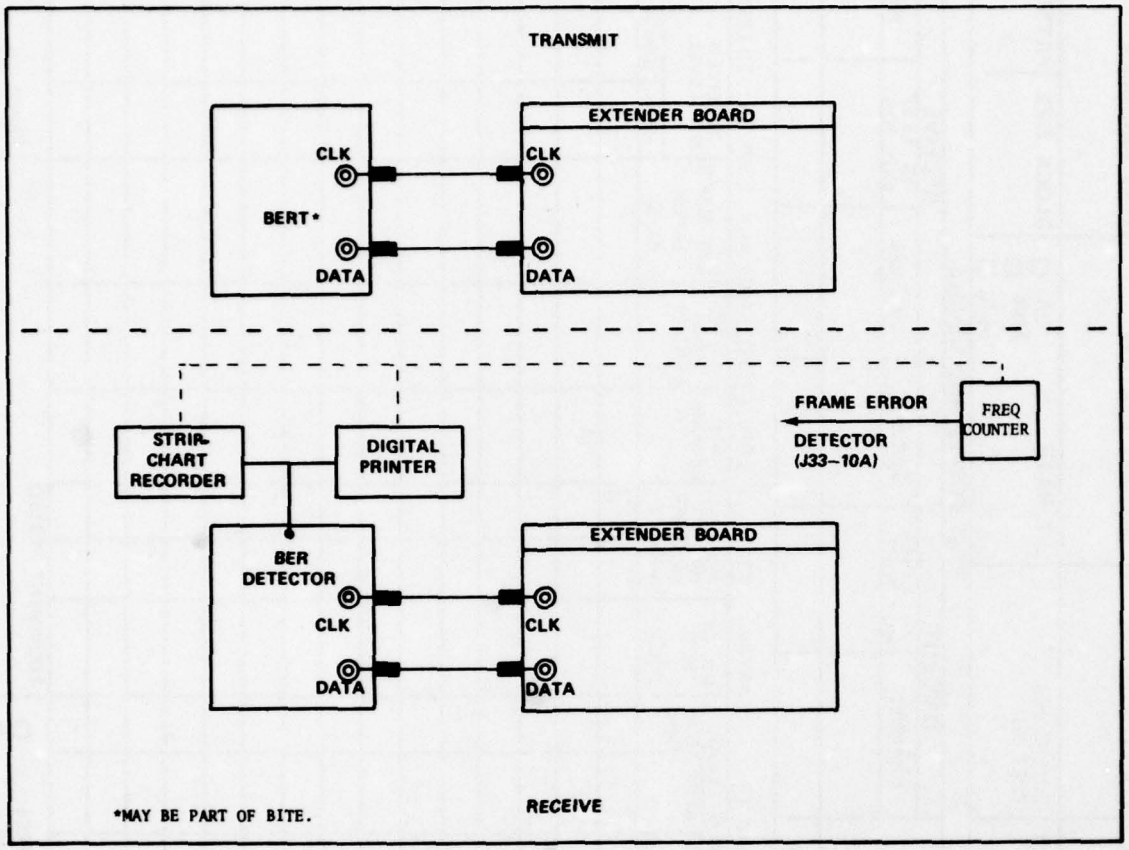


Figure 89-2. TD-1192 (AN/FCC-98) BER and BCI test setup using extender board.

CCP 702-11

DATA ERROR RATE
(MULTIPLEX)
(CCR 702-1-3)

DATA SHEET

PAGE OF PAGES

DATE (DAY, MO., YEAR)

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER	
1ST LVL MUX CHAN NO.	2D LVL MUX PORT NO.	BIT RATE b/s ☐ kb/s ☐ mb/s ☐	BLOCK SIZE	PATTERN

TEST POINTS AND LEVELS

	TRANSMIT			RECEIVE		
	CHANNEL	2D LEVEL MUX PORT	MBS OUT	CHANNEL	2D LEVEL MUX PORT	MBS OUT
TEST POINT						
LEVEL (VPP)						

SYNC ☐ ASYNC ☐ LINK ☐ 1ST LEVEL MUX LOOP ☐ 2D LEVEL LOOP ☐

RUN NO.	RUN TIME PERIOD START z	STOP z	DUR MIN	NO. OF BITS XMTD	NO OF ERRORS	AVG BER %	BCI ERRORS	NO. OF BLOCK ERRORS	AVG BLOCK ERROR RATE	RECEIVED SIG LEVEL dBm	dBmO	MEDIAN RSL dBm

IN SPECS: ☐
OUT OF SPECS: ☐

EQUIPMENT TESTED

	YES	NO
RECORDED		
AVERAGED		

COMMENTS

USACC FORM 666-R Figure 89-3. Data error rate (multiplex) data sheet.
1 MAY 79

CHAPTER 90

TD-1192 (AN/FCC-98) BIT ERROR RATE AND BIT COUNT INTEGRITY USING BITE (DT-287)

90-1. GENERAL.

a. The purpose of this test is to verify the data channel alinement, BER and BCI of the TD-1192 (AN/FCC-98) using the BITE insofar as possible.

b. This test may be performed in a local multiplex loop or over the link through a series of multiplex terminals.

c. The TD-1192 (AN/FCC-98) 1st level digital multiplex mimimum digital channel capacity based on the channel version in use is shown in figure 89-1. These data rates are obtained by substitution of the data interleaving cards with the voice frequency channel cards. The digital data cards will insert the digital data directly into the output bit stream and extract the digital data from the input data stream. The digital data cards will insert into and extract the digital data from the channel time slot or slots that the replaced voice channel or cards occupied. Insertion of a digital data card will inhibit E&M signaling for the replaced voice frequency channels.

d. This test may be performed on contractor EF&I systems to ensure that they meet performance specifications. It may also be used by installer or quality assurance personnel as directed.

90-2. SPECIFICATIONS.

a. For the TD-1192 (AN/FCC-98) criteria, refer to paragraph 89-2a.

b. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

90-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. Oscilloscope.

c. BER test set.

d. Digital recorder.

e. Impedance matching network, as required.

f. BITE.

90-4. TEST PROCEDURES. These procedures will be performed for each data module and data rate for both directions of transmission.

a. Data Module Checks with 0 to 20 and 50 kb/s.

(1) On the receive communications module, set the loop toggle switch to the up position.

(2) Verify that the digital transmit interface output loss, power alarm local loop, and carrier group alarm lamps illuminate.

(3) On the BITE, set the digital function rotary switch to 20- or 50-kb/s position depending on the module being tested.

(4) Connect the BITE and the module under test as shown in figure 90-1 or 90-2 depending on the module data rate.

(5) On the BITE, set the balanced/unbalanced toggle switch in the balanced position for the 0- to 20-kb/s module. For the 50-kb/s module, use the position shown in table 90-1 depending on the strapping option.

Table 90-1. 50-kb/s Data Module Strapping

OPTION INPUT/OUTPUT	STRAP	
	S1	S2
78 ohms (balanced) 50 ohms (unbalanced	Closed - on Open - off	Open - off Closed - on

(6) On the BITE, press the transmit error inject pushbutton momentarily and observe that the BER lamp lights and that the synchronous indicator remains illuminated.

b. Multirate Data Module Checks.

(1) Connect the BITE to the channel card under test as shown in figure 90-3.

(2) Repeat paragraphs 90-4a (1) through (6), above.

c. End-to-End Testing with the 0- to 20- and 50-kb/s data modules.

(1) For this part of the test, place the 0- to 20-kb/s module on an extender card and connect the equipment as shown in figure 90-4. This figure depicts a test arrangement for simultaneously transmitting and receiving in both directions.

(2) On the BITE, set the rotary functions switch to 20 or 50 kb/s depending on the data module being tested.

(3) Set the balanced/unbalanced switch according to table 90-1.

(4) At the transmit end, send data for approximately 5 minutes from the built-in pattern generator.

(5) At the receive end, record the data on figure 89-3 (USACC Form 666-R).

d. End-to-End Testing with Multirate Data Modules.

(1) At the transmit and receive ends, place the data module under test on an extender board and connect the equipment as shown in figure 90-4.

(2) Set the digital function switch to external clock and set the balanced/unbalanced switch to balanced.

(3) At the transmit end, send data for approximately 5 minutes. At the receive end record the number of data errors, frame errors, and other pertinent data on figure 89-3 (USACC Form 666-R).

90-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and verify that the equipment meets the end-to-end performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

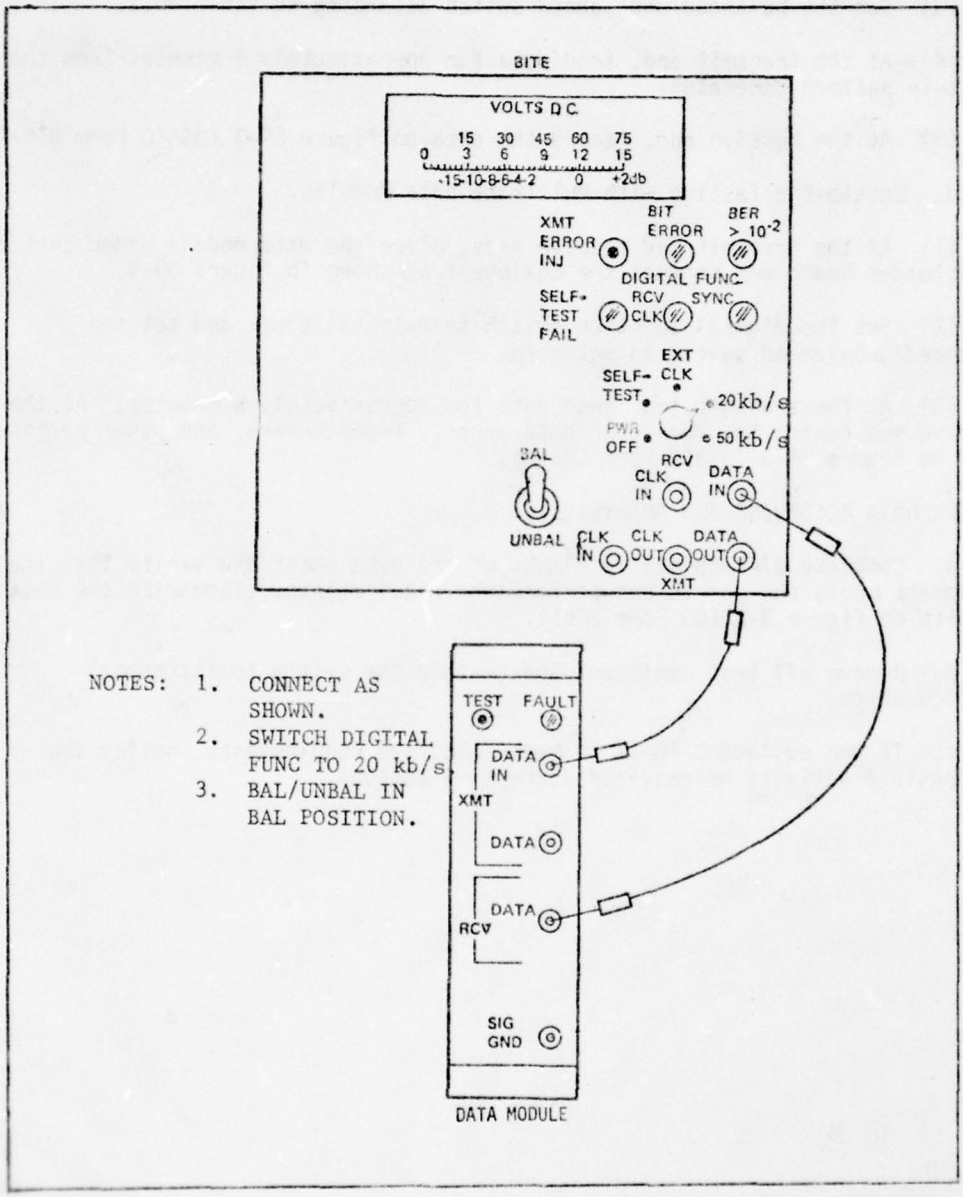


Figure 90-1. Asynchronous data module (0 to 20 kb/s) test setup.

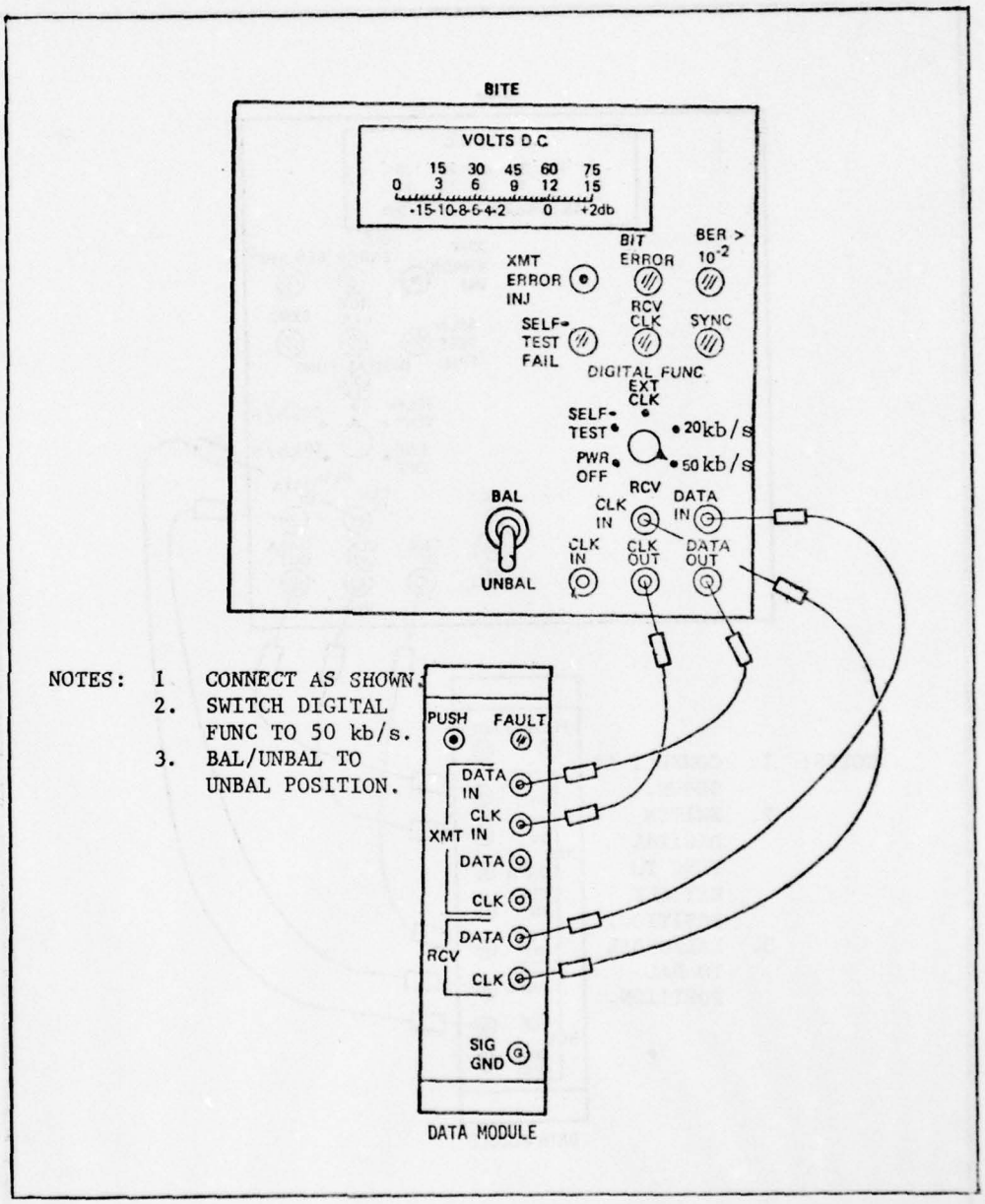


Figure 90-2. Asynchronous data module (50 kb/s) test setup.

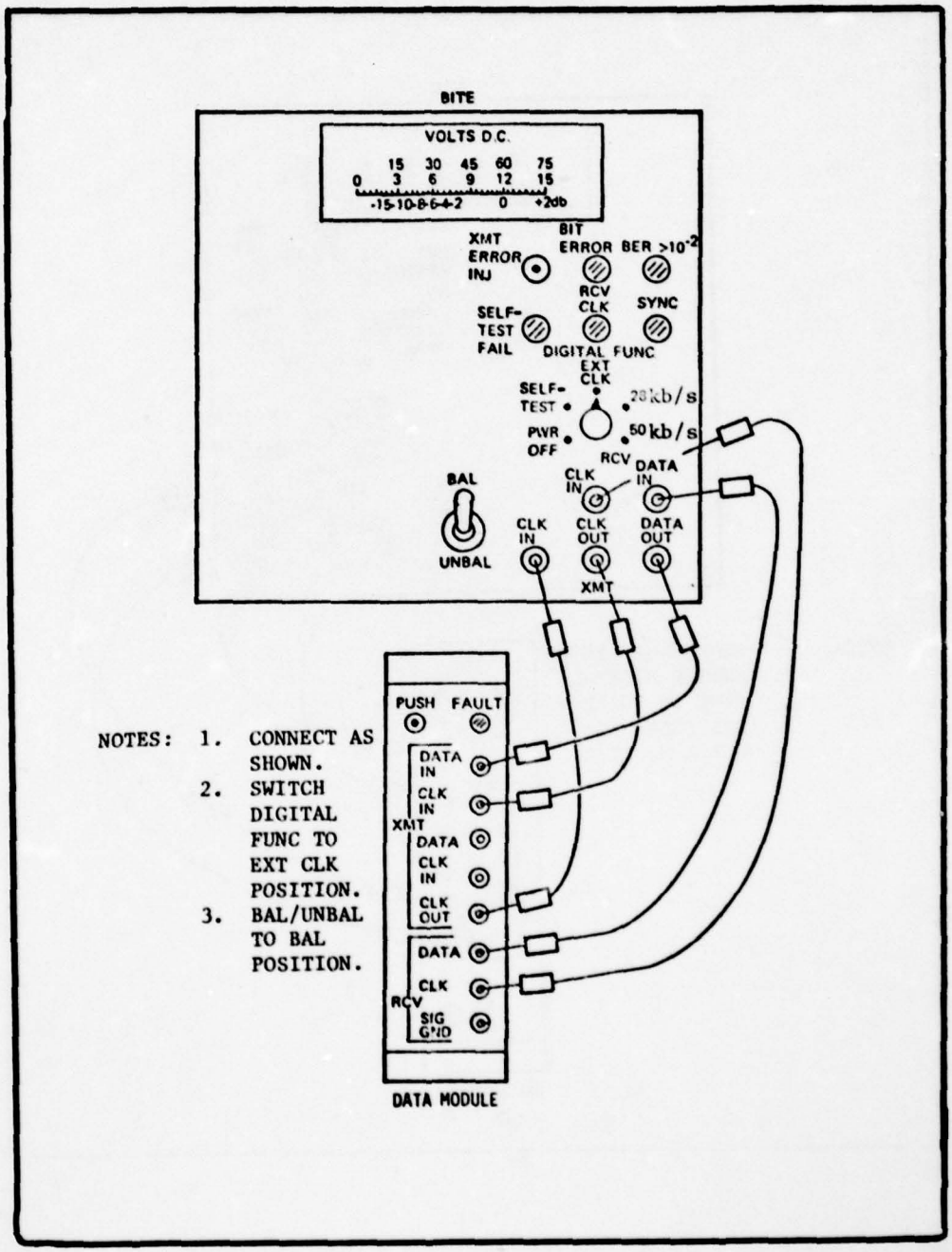


Figure 90-3. Multirate data module test setup.

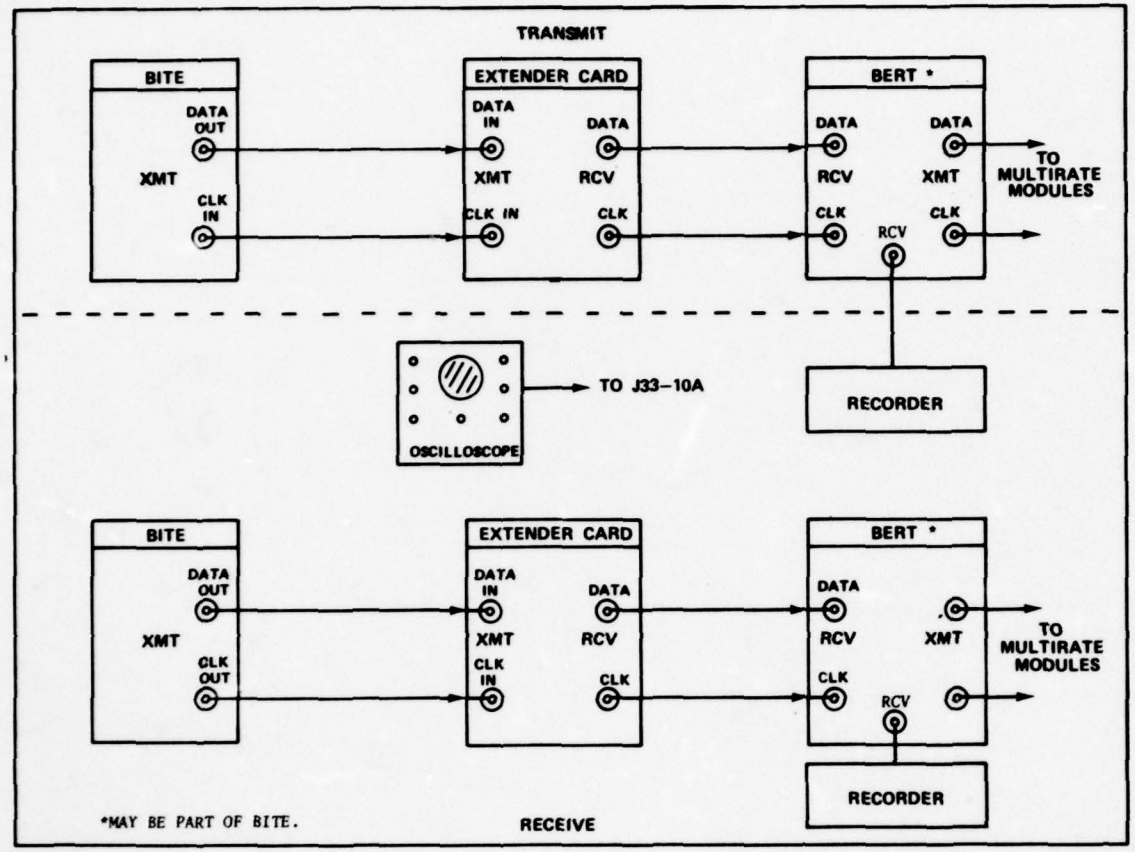


Figure 90-4. Multirate data module (simultaneous transmit and receive) test setup.

CHAPTER 91

BIT ERROR RATE AMD BIT COUNT INTEGRITY OF THE VICOM 4000-2 (DT-288)

91-1. GENERAL.

a. The purpose of this test is to measure the bit-by-bit correspondence between the VICOM 4000-2 port input and port output in a loop configuration. The BCI will be measured to verify that synchronization between the transmit and receive bit streams of the system remain intact allowing true correspondence between transmitted and received bit streams.

b. This test will demonstrate the VICOM 4000-2 multiplex equipment performance BER under various S/N conditions as well as determine the BCI at different S/N levels.

91-2. SPECIFICATIONS.

a. The measurement of errors in a 10^8 bit bime period for the VICOM 4000-2 shall not exceed 6 errors (an average of 3 consecutive test periods) for a 95-percent confidence factor of a 10^{-7} BER. The peak-to-peak RMS noise ratio shall be 28 dB for the 10^{-7} BER.

b. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

91-3. TEST EQUIPMENT REQUIRED.

a. Video patch cables.

b. Noise test set (Marconi 2090) with low-pass filter TK-2045/G.

c. Variable attenuator HP 3750A.

d. Resistive adder (75 ohms).

e. Amplifier (26 dB) (Raytheon).

f. Low-pass filter (Raytheon 898018 or equivalent 4.4 MHz at the 3-dB point, 8.1 MHz at the 15-dB point.

g. RMS voltmeter.

h. Oscilloscope.

i. Frequency counter (HP 5326A or equivalent).

j. Recorder.

91-4. TEST PROCEDURES. The following procedures will be repeated for each direction of transmission.

a. Bit Error Rate.

(1) *Preliminary test setup.*

(a) Place the multiplexer protection switch unit trarsmit switch common and receive switch common front panel switches transfer to standard/reset to normal switches in the down position and the automatic transfer disable switches in the up position. This places the VICOM 4000-2 multiplexer occupying the upper portion above the protection switch (the normal multiplexer) in operation. Allow approximately 30 minutes for warmup and stabilization.

(b) Connect the VICOM 4000-2 normal multiplexer as shown in figure 91-1. Connect a video patch cable between J8-N (the to transmitter of the protection switch 4031 block assemply; point A indicated on the figure) and the input to attenuator AT-2. Connect another video patch cable between J10-N (the from receiver jack at the protection switch 4031 jack block assembly; point A indicated on the figure) and the output of attenuator AT-3.

(c) Connect the multiplexer transmit and receive channels 1 through 8 as shown in figure 91-1.

(d) Connect the normal multiplexer 4027-01 test word generator-detector module and frequency counter as shown in figure 91-1.

NOTE: The length of cable from the word generator-detector for mount clock to the counter oscillator connector should be kept as short as possible (less than 3 feet) as the counter input at this point is not 75 ohms but a high impedance point. At the rear of the counter, set the internal/external clock switch to external.

(e) Set attenuator AT-1 at the 40-dB setting. Set AT-3 at 0 dB. Adjust AT-2 for a nominal 26-dB setting.

(f) Using the oscilloscope, observe and record the peak-to-peak signal at point A. A nominal peak-to-peak signal level of 1.0 volt is typical.

(g) Disconnect the cable between AT-3 and point A. Connect a cable between AT-3 and the input to the low-pass filter (Raytheon 898018). The filter is terminated at its output in 75 ohms. With AT-3 still set at 0 dB, adjust AT-2 for an observed eye pattern of 1.5 VPP at the output of the band-pass filter.

(h) Without changing the setting of AT-2, adjust attenuator AT-3 for an observed eye pattern of 1.0 VPP at the output of the low-pass filter.

(i) Disconnect the cable between AT-3 and the low-pass filter. Reconnect the cable between point A and AT-3.

(j) Place the normal multiplexer 4040 interface module on an extender card and connect the oscilloscope probe between the base of Q2 and ground. The oscilloscope display will be the NRZ output waveform. Observe the waveform for vertical symmetry; that is, the vertical crossover point should be at the center (50-percent point) of the interval between the two states. Resistor R2 on the 4090 interface board determines the duty cycle. If required, adjust R2 for a 50-percent duty cycle waveform by placing the appropriate value of resistance in parallel with R2 (1/4-watt, carbon composition type, typically several kilo-ohms; for example, 7.5 kilo-ohms).

(k) Next, set the threshold level indicator of the counter to read above the noise. The front panel level indicator should flash only when the 4027 word generator-detector error injection button is held down. When the button is held down for approximately 6.5 seconds and the counter time base/multiplier is set at 10^7, the counter readings will each be 305 errors.

(2) Measurement.

(a) Using the test setup described in paragraph 91-4a(1), above, adjust AT-3 for a 1.0 VPP signal at the low-pass filter output.

(b) Disconnect the cable between AT-3 and point A1. Connect a cable between AT-3 and the input to the low-pass filter (Raytheon 898018). The filter is terminated at its output in 75 ohms. With AT-3 set at 0 dB, adjust AT-2 for an observed eye pattern of 1.5 VPP at the output of the bandpass filter.

(c) Disconnect the video patch cable between point A and the input to attenuator AT-2. Terminate the attenuator input in 75 ohms.

(d) Initially adjust AT-1 for an RMS noise voltage reading of 40 mV at the output low-pass filter using the RMS voltmeter (the noise voltage of 40 mV RMS is equivalent to a peak-to-peak SNR of 28 dB).

(e) Reconnect the video patch cables as indicated in paragraph 91-4a(1) (b), above, and remove the low-pass filter from the circuit.

(f) Set the counter time base/multiplier to the 10^8 position. Press the counter reset button to start the time period (each time period is approximately 65 seconds at the 10^8 setting). Observe three successive counter readouts of BER. From this data, determine by additional measurements, if necessary, the S/N threshold point (maximum S/N) that produces a zero in 10^8 BER). Record the threshold value in mV and make three successive counter readouts of BER at threshold.

(g) Repeat the test for an S/N of 32 dB, and at the S/N's shown in table 91-1, if directed.

Table 91-1. Bit Error Rate vs SNR

S/N (dB)	S (SIGNAL p-p) (VOLTS)	N (RMS NOISE) (mV)	COUNTER MULTIPLIER SETTING	NUMBER OF TRIALS	TIME PERIOD OF EACH TRIAL
28	1.0 0.5 1.5	40 20 60	10^5	3	65 msec
29	1.0 0.5 1.5	35 17.5 52.5	10^6	3	0.65 sec
30	1.0 0.5 1.5	31 15.5 46.5	10^7	3	6.5 sec
31	1.0 0.5 1.5	28 14 42	10^8	3	65 sec
32	1.0 0.5 1.5	25 12.5 37.5	Manual*	1	10.8 min

*Use of HP 5245L counter, internal time base.

(h) Repeat the above procedure for the standby (lower) TDM.

(i) Record the test results on figure 89-3 (USACC Form 666-R).

b. Bit Count Integrity.

(1) Preliminary test setup.

(a) Place the multiplexer protection switch unit transmit switch common and receive switch common front panel switches transfer to standard/reset to normal switches in the down position and the automatic transfer disable switches in the up position.

(b) Connect the VICOM 4000-2 normal multiplexer in a loopback by connecting a video patch cable between J8-M and J10-M (the to transmit-monitor and from receive-monitor jacks of the protection switch 4031 jack block assembly. Refer to points A and A1 of figure 91-2.

(c) Connect the multiplex receive channel inputs to the appropriate transmit channel outputs at the normal multiplexer 4106 PCM access units as shown in figure 91-2; for example, receive channel 2 at channel 2 PCM access unit from multiplexer jack to transmit channel 3 at the channel 3 PCM access unit to multiplexer jack.

(d) Connect the bipolar output and input jacks of the TSEC/CY-104 interface unit patch field to the VICOM 4000-2 normal multiplexer PCM access units as shown in figure 91-2.

(e) Connect a recorder to the frame error detector as shown in the figure.

(2) *Measurement.*

(a) At a convenient start time, press the frame reset switch on the front panel of the 7070 power and alarm unit (a module of the TSEC/CY-12 portion of the TSEC/CY-104). This pushbutton extinguishes the frame light when the terminal reframes.

(b) Record the reframes for 24 hours or each hour during the test period. Observe if the frame light is illuminated on the 7070 power and alarm subassembly.

(c) If the frame light is illuminated at the time of any hourly reading (before the 24-hour test period has elapsed), record the hour of occurrence and terminate the test.

(d) Upon premature termination of the BCI tests, as outlined in subparagraph (c), above, repeat the test for an additional 24 hours.

91-5. DATA RECORDING AND ANALYSIS.

a. Record all data on figure 89-3 (USACC Form 666-R). Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

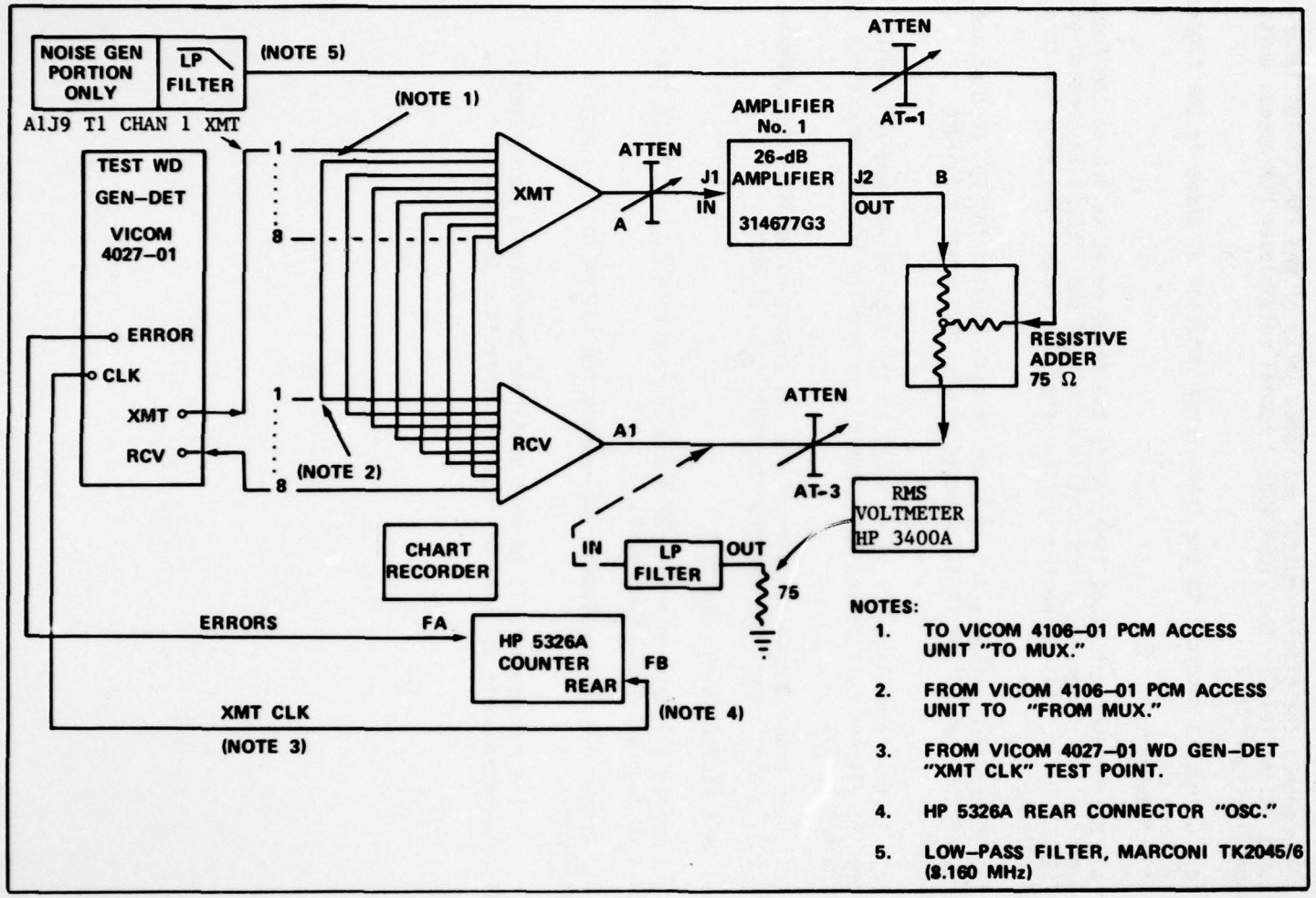


Figure 91-1. BER test setup (VICOM 4000-2).

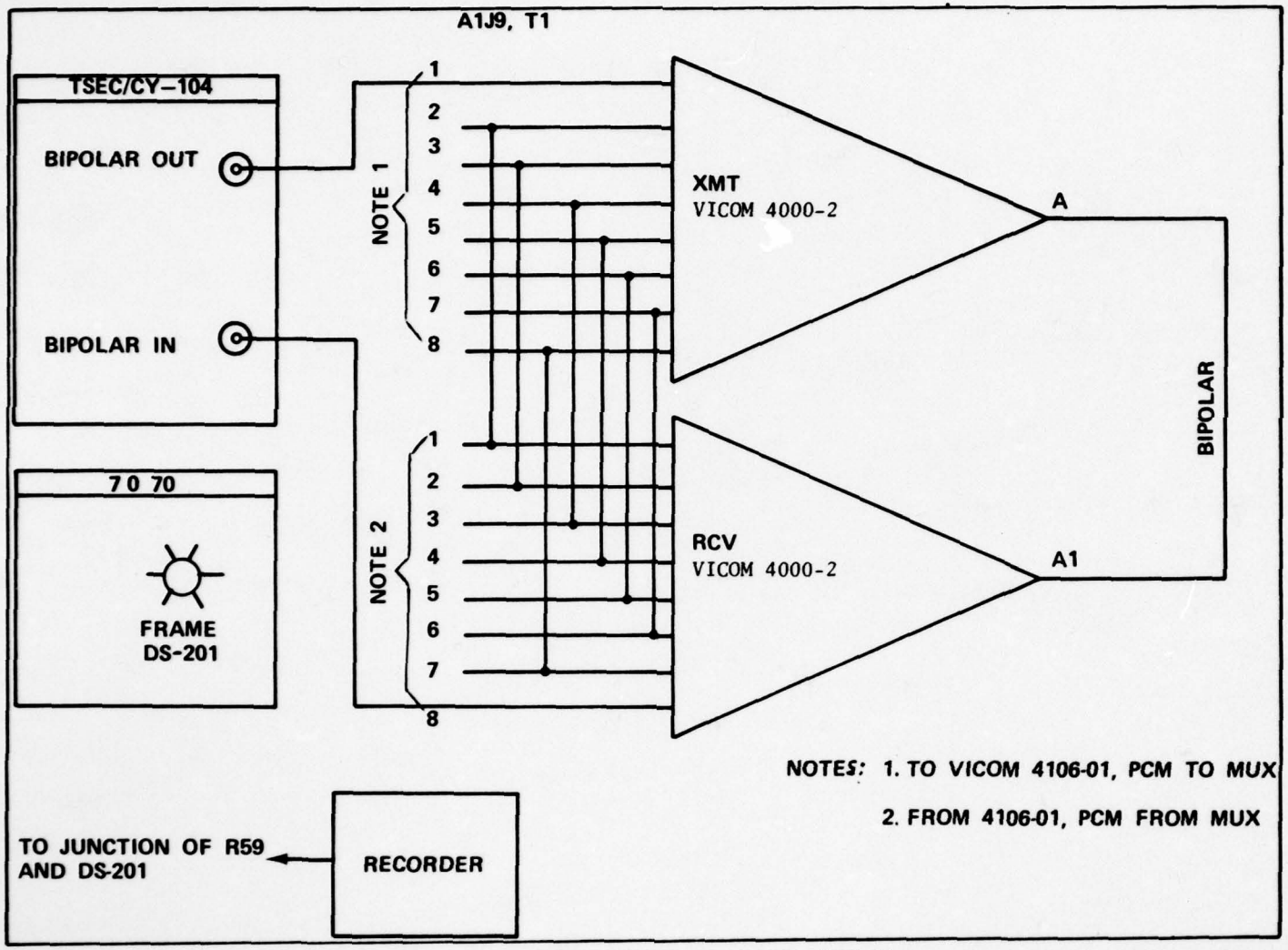


Figure 91-2. BCI test setup (VICOM 4000-2).

CHAPTER 92

BIT ERROR RATE AND BIT COUNT INTEGRITY OF THE 2D LEVEL MULTIPLEX (1.544 mb/s AND ABOVE) (DT-289)

92-1. GENERAL.

a. The purpose of this test is to determine the BER and BCI performance of the 2d level digital multiplex equipment.

b. This test may be performed at the data patch panel, at the equipment input/output ports, or at other accessible test points within the station.

c. The TD-1193 is designed to accept a range of data inputs/outputs by strapping options available at the data ports. Depending on the strapping, the input/output would be eight (1.544 mb/s ±200 b/s for a single port; 3.088 mb/s ±400 b/s with two ports strapped; and 6.176 mb/s ±600 b/s with four ports strapped). The port options, nominal data rate, and signal format are shown in table 92-1.

d. The VICOM 4000-2 2d level multiplex as used in the existing digital systems in the European area is only concerned with the 1.544 mb/s input rate.

e. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

92-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1193 2d level multiplexer. (CCC-74048)

(1) With the TDM in frame synchronization and receiving data with a BER of zero, the BER at any port and strapped port output shall not exceed $1x10^{9}$.

(2) While the multiplexer remains in frame synchronization, the mean time between loss of BCI at any asynchronous output port shall not be less than 6 hours when the MBS signal is perturbed by the occurrence of randomly distributed errors as high as $1x10^{-2}$. While the demultiplexer remains in frame synchronization, no loss of BCI shall occur at any synchronous output port when the MBS signal conditions stated above for asynchronous port exist. Refer to figure 92-1.

(3) With a stable input data rate within the tolerance shown in table 92-1 provided as an input to the first of five consecutive multiplexing and five consecutive demultiplexing functions using three or more TDM's, there shall be no loss of BCI in any of the five equipments. The slewing characteristics at the output of the 5th TDM demultiplexer shall be as specified below.

Table 92-1. Digital Characteristics, TD-1193 vs Port Options

PORT OPTIONS	NOMINAL DATA RATE (mb/s)	NOMINAL TIMING RATE (MHz)	NOMINAL DATA UNIT INTERVAL (μsec)	NOMINAL TIMING PULSE WIDTH (μsec)	DATA SIGNAL FORMAT	TIMING SIGNAL FORMAT
Single port	1.544 ±200 b/s	1.544	0.6477	0.3238	NRZ and bipolar	Polar square wave
Two-strapped port	3.088 ±400 b/s	3.088	0.3238	0.1618	NRZ	
Four-strapped port	6.176 ±600 b/s	6.176	0.1619	0.0809	NRZ	

b. At normal operating conditions with a VICOM 4000-2 loopback and without injecting external noise at the input to the receive multiplex, the 10^8 bit samples for BER shall not indicate any errors for the test period. The BCI recorded over a 24-hour period shall indicate no frame alarms over the test period.

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

92-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Oscilloscope.

c. BITE.

d. Digital recorder.

e. Stripchart or event recorder.

92-4. TEST PROCEDURES. The BITE may be used to check out the port module performance; however, it must be supplemented with additional test equipment to determine the BER and BCI, especially on the 2d level multiplexer. Also the BITE pseudorandom generator and detector may not accommodate all required data rates.

a. TD-1193 (2d Level Multiplex).

(1) *Built-in test equipment.*

(a) Before beginning the test, determine the nominal data rate and signal format based on table 92-1 or perform a physical inspection of the equipment strapping options.

(b) If using the BITE, perform a self-test of the BITE in accordance with the equipment manual and verify that it is working properly.

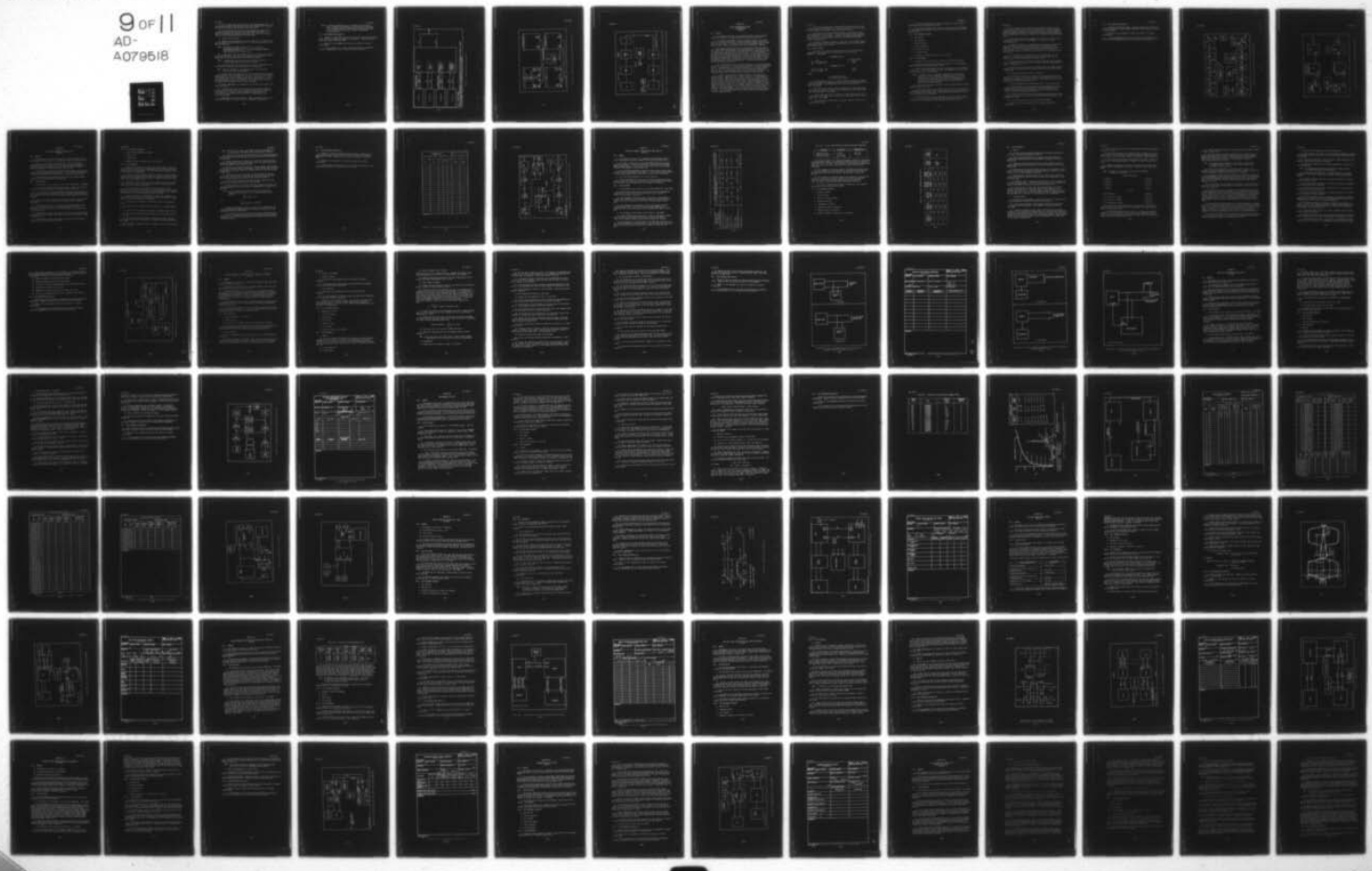
(c) Connect the port under test as shown in figure 92-2 by patching the BITE to the port input/output. Set the BITE format switch to NRZ or bipolar as determined in subparagraph (a), above. Allow approximately 30 minutes for warmup and stabilization.

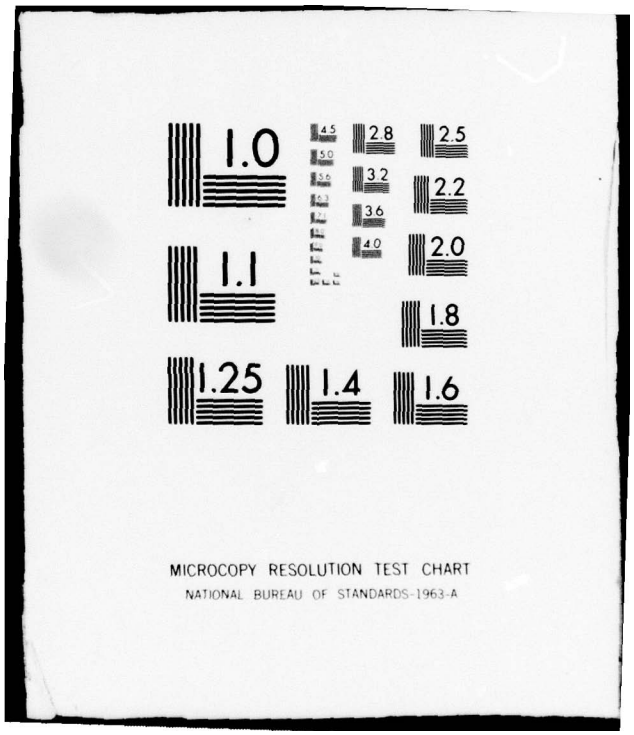
(d) At the transmit and receive ends, turn the BITE selector switches to on-normal.

(e) At the receive end, connect a recorder or event counter to the frame error test point or any convenient access point within the equipment. Connect an external BER test set to the external error connector on the rear panel of the multiplexer.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

9 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(f) At the transmit end, press the error injection pushbutton switch. At the receive end, observe that the frame error event recorder counts the events. Also the error light on the BITE should flicker on and off.

(g) At the transmit end, send data for approximately 15 minutes while recording the BER and BCI events on figure 89-3 (USACC Form 666-R). If desired, the transmit test period may be broken into 3 runs of 5 minutes for each run and the average BER entered on the data sheet.

(2) External test equipment.

(a) Connect the test equipment as shown in figure 92-3. The BER test set may be connected to the data patch panel or the signal injected directly into the port under test.

NOTE: The N-terminals shown in figure 92-3 may be up to five multiplexers and demultiplexers connected in tandem. The interconnecting cable should not exceed 100 feet for high data rates and 750 feet for low data rates.

(b) At the transmit end, set the BER test set for the data rate and format of the port under test. Set the test set input/output for 78 ohms at 1 VPP. Measure and record the peak-to-peak input and output voltages.

NOTE: If the BER test set does not provide a 78 ohm ±10 percent balanced input/output, use an interface device.

(c) Set the BER test set to send and receive a 20-bit pseudorandom signal. Verify that all alarm lamps at both terminals are extinguished.

NOTE: Refer to the BER test set operating manual for setting other function switches of the equipment.

(d) Transmit data at the applicable bit rate for 15 minutes while recording the total bit errors and frame errors at the receive end. The 15 minutes may be broken into 5-minute intervals to arrive at a run average. If using the run average method, set the receive BER test set for manual start/stop with a gating period equal to the run time period. At the end of each run, record the elapsed time and number of errors on the data sheet.

(e) Repeat subparagraphs (a) through (d) for each data port and data rate. Record the results.

(f) In the BCI part of the test, if testing to the equipment specifications, record the frame errors for 6 hours while observing that the BER does not exceed 10^{-2}. If required, inject randomly distributed errors of 10^{-2} into the MBS and note that no loss of BCI or frame synchronization occurs at the output.

b. VICOM 4000-2 (2d Level Multiplexer). Refer to DT-288 or use the procedures described above and modify to meet the VICOM 4000-2 requirements.

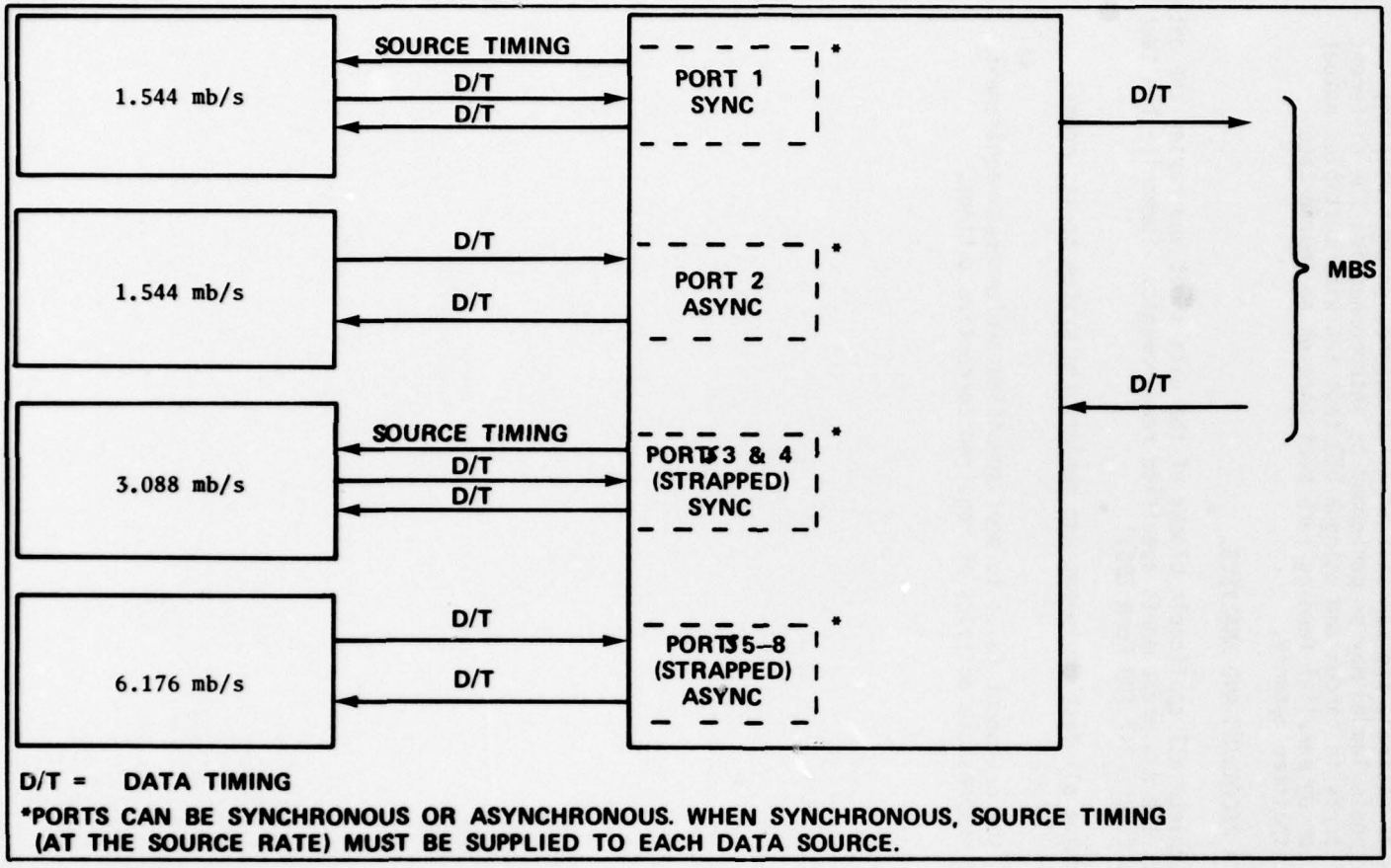
NOTE: If desired, the BER test of a T-1 channel or port with all ports loaded may be performed by interconnecting the different ports in tandem and using a BER test set with multiplex output or by parallel feeding each port through an appropriate splitter network.

92-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheet and review the data to verify that the equipment meets specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.



CCP 702-11

92-6

Figure 92-1. Strapping options at data ports.

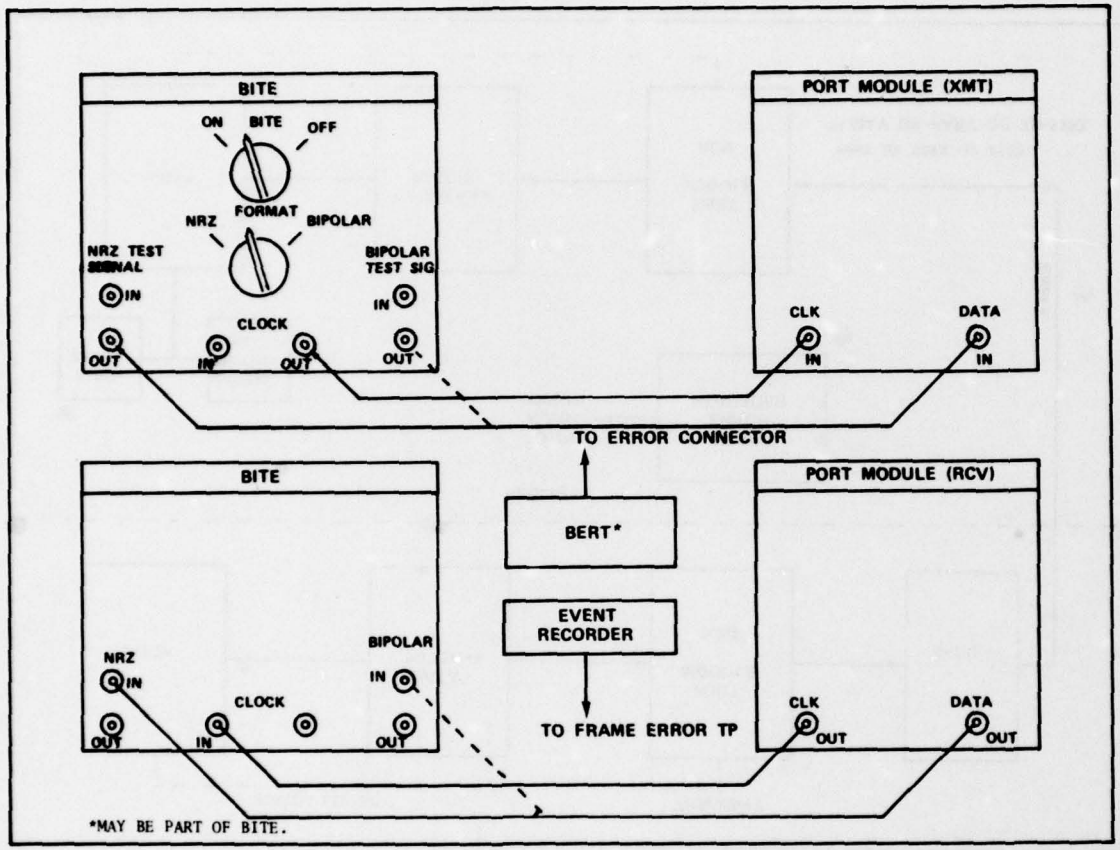


Figure 92-2. BER and BCI of 2d level multiplex (BITE) test setup.

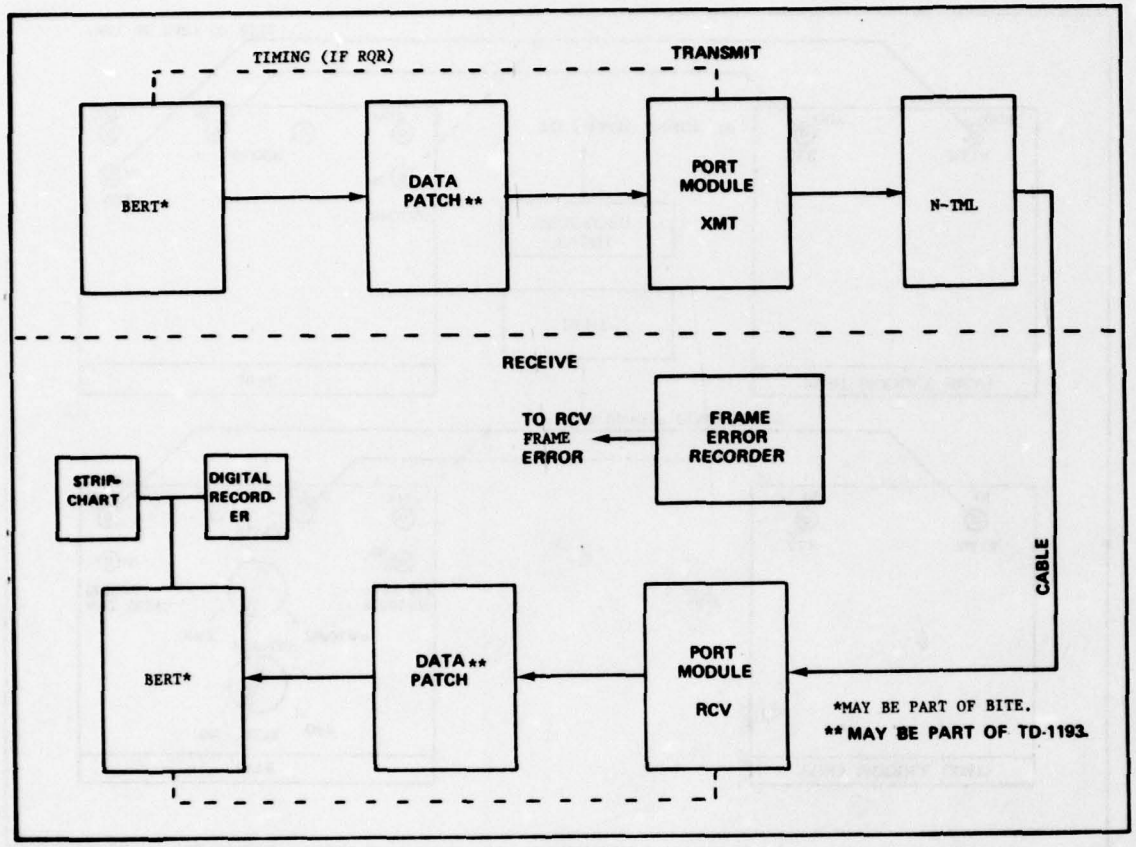


Figure 92-3. BER and BCI of 2d level multiplex (external test equipment) test setup.

CHAPTER 93

DIGITAL TRANSMISSION SYSTEM BIT ERROR RATE (DT-290)

93-1. GENERAL.

a. The purpose of this test is to determine the BER with the equipment connected as a system on an end-to-end basis as shown in figure 93-1.

b. This test may be performed at any of the points shown in the figure either on a system or loop basis. Since the preceding chapters provide procedures for back-to-back loop testing of the individual equipment, they are not repeated herein, except as necessary to provide a complete test sequence.

c. The primary purpose of this test is to determine whether the digital radio and multiplex are operating in an optimum condition. An analysis of the link digital error characteristics is the best method for determining the overall performance of the digital portion of the link. If the link performs according to specification (with the specified RSL), the link digital radio and multiplex can be considered satisfactory. If the error measurements are not satisfactory, perform additional detailed multiplex and radio tests to isolate and repair the difficulties. Regardless of the results of the digital radio and multiplex tests, measure the performance of the analog-to-digital and digital-to-analog voice processors.

d. The average BER per run is defined as the number of bit errors measured during the run interval, divided by the total number of bits transmitted during the run. The average BER is related to the median RSL. To obtain a range of RSL's, an artificial variation of the RSL can be produced by varying the receiver input by inserting attenuation at the receiver input terminals. The attenuator may be used to determine the relationship of BER versus RSL.

e. To enable further analysis of BER distributions, the BER test set should be used in conjunction with a digital recorder. This instrument will normally present a paper tape record of time, random error, bursts of errors as well as clock loss or drop of synchronization, count overflow, and indications of unusual conditions of the data stream. With some BER test sets, it is possible to obtain a block error rate as well as a BER. In general, it may be possible to select a block size (for example, 10,000 bits) and to select the number of bits which must be in error within the block to cause the block to be counted in error (for example, 5 bits in error causes 1 block error to be counted). This added capability permits a better analysis of the distribution of errors in that selected bursts of errors can be electronically separated from the random bit errors.

f. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

g. Procedures for recording the BER versus RSL are provided in DT-311. This method should be used whenever a long-term (more than 72 hours) performance characteristic of the system is required. The method described herein is primarily based on short-term sampling of the data and comparing the BER results to the median RSL.

h. Individual equipment performance as contained in the preceding chapters should be performed to verify that the equipment meets specifications before performing this test on a link basis.

93-2. SPECIFICATIONS.

a. For an RSL 20 dB above that determined from the following formulas, the BER shall not exceed $1x10^{10}$ bits 95 percent of the time on the AN/FRC-( ). (CCC-74049)

PERFORMANCE LEVEL I

RSL	RSL FROM A BER OF
$-164 + 10 \log_{10} R + NF$	$5x10^{-2}$
$-157 + 10 \log_{10} R + NF$	$5x10^{-9}$

PERFORMANCE LEVEL II

$-158 + 10 \log_{10} R + NF$	$5x10^{-2}$
$-151 + 10 \log_{10} R + NF$	$5x10^{-9}$

where:

R = aggregate bit rate
NF = receiver noise figure

b. The measurement of errors in a 10^8 bit time period shall not exceed 6 errors (an average of 3 consecutive test periods) for a 95-percent confidence factor of 10^{-7} BER. The AN/FRC-162 RSL shall be -71 dBm for the 10^{-7} BER. (CCC-73017)

c. With the multiplex terminal TD-1192 (AN/FCC-98) in frame synchronization and receiving data with a BER of zero, the BER at any data channel output shall not exceed $1x10^7$. (CCC-74047)

d. With the multiplex terminal (TD-1193) in frame synchronization and receiving data with a BER of zero, the BER at any data channel output shall not exceed $1x10^9$. (CCC-74048)

e. The AN/FRC-162 and VICOM 4000-2 system shall operate as specified in subparagraph b, above.

f. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

g. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

93-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Oscilloscope.

c. Digital recorder.

d. Digital voltmeter.

e. Stripchart recorder.

f. Turnaround mixer.

g. Attenuators, adapters, cables, etc., as required.

93-4. TEST PROCEDURES.

a. Complete all applicable blocks of figure 89-3 (USACC Form 666-R).

b. Connect the test equipment as shown in figure 93-1 and allow approximately 30 minutes for warmup and stabilization.

c. At the transmit and receive ends, set the BER test set to correspond to the data rate, signal format (NRZ or bipolar), and impedance of the test point at which the test is to be performed.

NOTE: If the BER test set input/output impedance does not match the equipment test point, balanced or unbalanced, use an interface device between the test set and the test point being used. As an example, if inserting the test set into the TD-1193 aggregate bit stream input with bipolar option, it should be set for 100 ohms ±10 percent (balanced).

d. At both terminals, measure the VPP at the test points shown on the data sheet and record the levels.

e. At the transmit end, set the data output rate, level, and word length to correspond to the channel, port, or MBS at the point of data insertion. Set the remaining controls and switches in accordance with the operating instructions supplied with the instrument.

f. At the receive end, set up the BER test set, digital printer, and/or stripchart recorder according to the instrument's operating instructions. Connect the input to the applicable test point as shown in figure 93-1.

g. At the transmit end, send data for approximately 5 minutes. At the receive end, record any errors on the digital printer at the RSL at which the system is operating. Record this data on the data sheet. If all equipment is functioning properly and the RSL is above the levels established in paragraph 93-2, the BER should not exceed the stated levels during the 5-minute recording period.

h. At the receive end, adjust attenuator AT-3 (fig. 93-1) for an RSL corresponding to a BER of $5x10^{-9}$ for the AN/FRC-( ) and $1x10^{-7}$ (-71 dBm) for the AN/FRC-162.

i. At the RSL established in subparagraph h, above, perform a minimum of three 5-minute runs and record the results on the data sheet. For the AN/FRC-( ), reduce the RSL from that established in subparagraph h, above, in 3-dB steps until an RSL corresponding to a BER of $5x10^{-2}$ is reached. At each 3-dB step, perform a 5-minute run and record the errors on the data sheet for each run.

j. For the AN/FRC-162, increase the RSL to -60 and -65 dBm. For the AN/FRC-( ), increase the RSL in 5-dB steps until a 10-dB spread has been obtained from the level established for a BER of $5x10^{-9}$

k. Plot the results of the individual runs on figure 29-4 (DD Form 2099). This will provide a representative plot of the BER versus RSL under varying RSL inputs to the receiver.

l. Use the initial test procedures that were used for the European digital system's test and acceptance when testing the AN/FRC-162 and similar multiplex installations.

(1) Connect the equipment as shown in figure 93-2.

(2) At the receive end, monitor the AGC of the radio at TP-3 or TP-4 as applicable. If this is an out-of-service test, adjust attenuator AT-1 for an AGC level corresponding to an RSL of -71 dBm. If the radio is in traffic, the standby receiver may be used for the test.

(3) Set the frequency counter time base/multiplier to the 10^8 position.

(4) With data being received from the transmit word generator, press the counter reset button to start the time period. Each time period will be approximately 65 seconds at the 10^8 setting. Record the three successive counter readings of the BER on the data sheet.

(5) To obtain a plot of BER versus RSL, adjust the attenuator for an AGC reading corresponding to -60, -65, and -75 dBm and repeat the procedure in subparagraph (4), above.

(6) Plot the BER versus RSL on figure 29-4 (DD Form 2099).

m. Repeat the applicable procedure for the opposite direction of transmission.

93-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheets and plot the test results on figure 29-4 (DD Form 2099). Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment/system fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

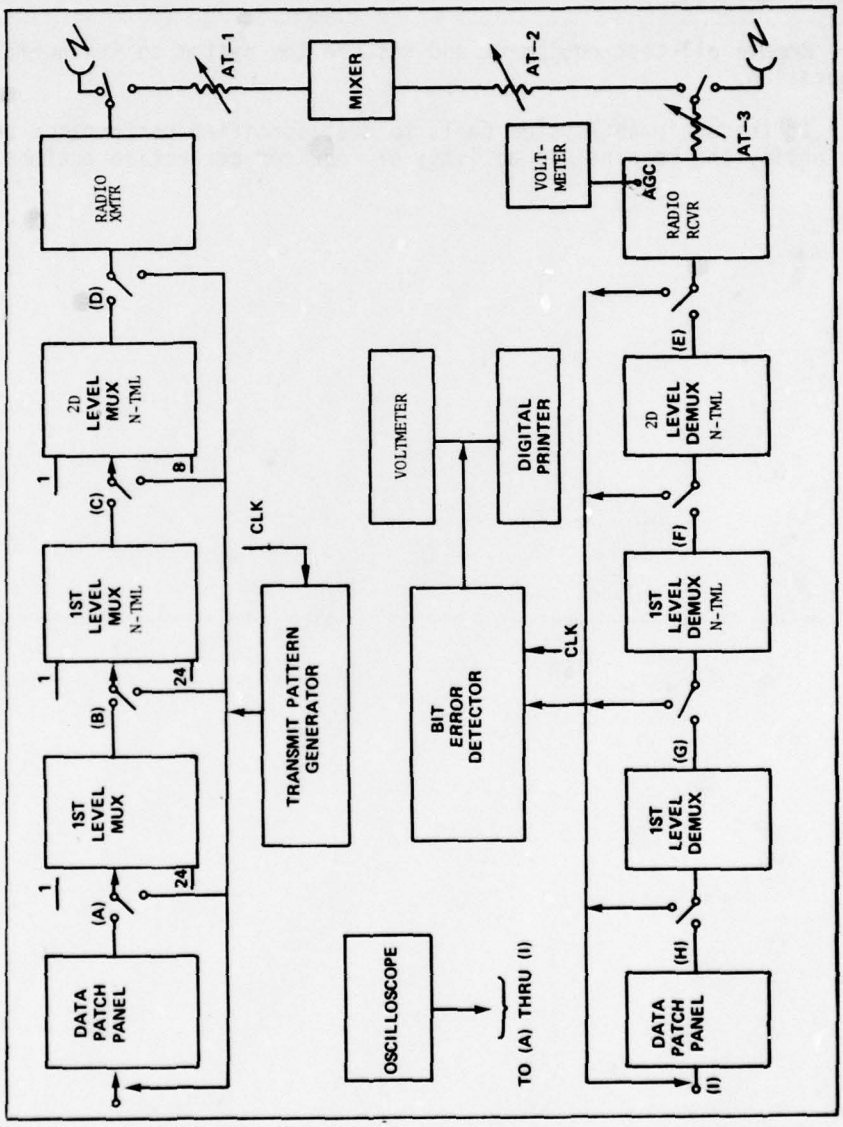


Figure 93-1. Digital transmission system BER test setup.

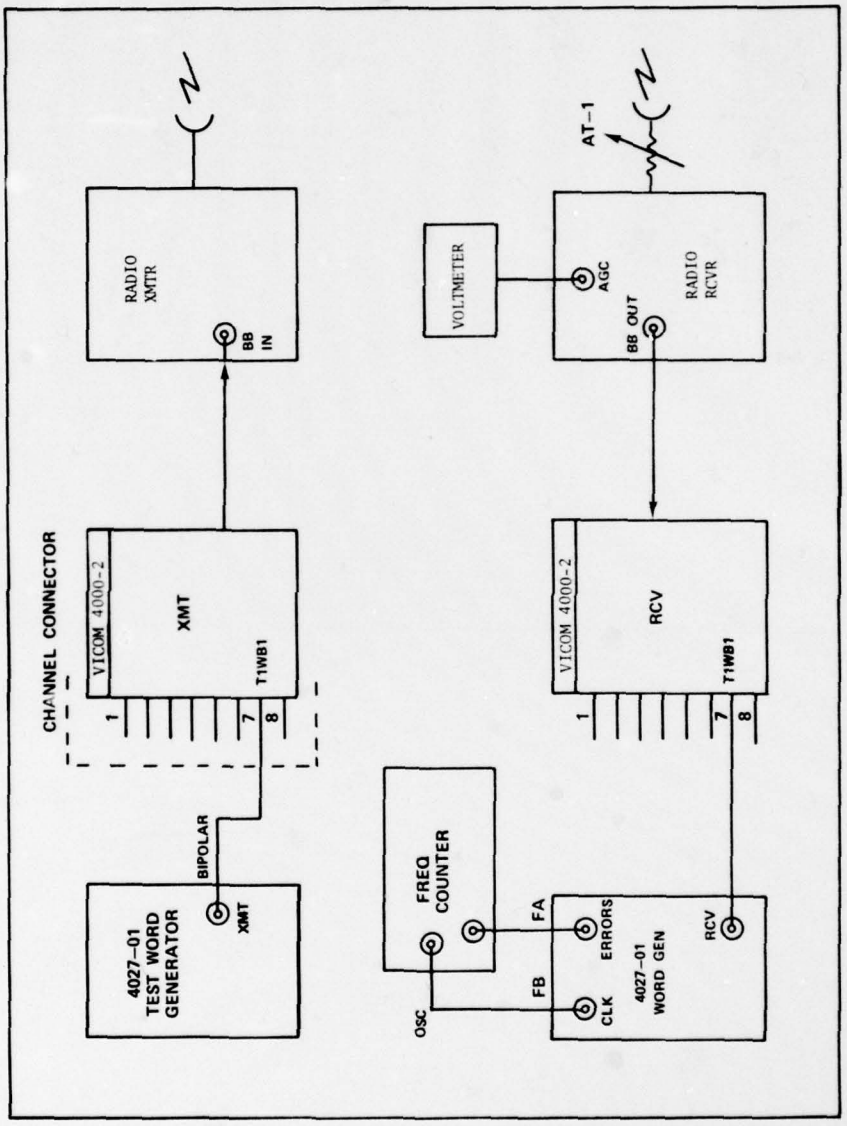


Figure 93-2. Digital transmission system BER (AN/FRC-162) test setup.

CHAPTER 94

SYSTEM DATA CHANNEL AND TIMING JITTER (DT-291)

94-1. GENERAL.

a. The purpose of this test is to measure the amount of timing jitter experienced by a digital signal in transversing a link or a multiple of links.

b. This test is primarily for measuring the jitter on the digital inputs/outputs of the multiplex and radio system. It may be performed on a link basis or with the equipment in a local loop configuration; however, it should be performed as a final systems test over the link.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

d. This test should be performed directly at the data channel outputs rather than at some intermediate data patch panel.

94-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) Jitter on the output data and timing signals, except for the 50-kb/s data, shall not exceed 2 percent of the nominal data unit interval.

(2) For balanced and unbalanced impedances, the peak individual phase distortion of the significant transitions of the timing signal when measured at the modulation rate of the 50-kb/s data channel output signals shall not exceed 5 percent.

b. Jitter on the output data and timing signals of the TD-1193 (2d level multiplex) shall not exceed 4 percent of the nominal data unit interval. (CCC-74048)

c. The measured peak jitter of the AN/FRC-162 and VICOM 4000-2 system shall be less than ±0.25 of a data bit which is measured as a total excursion of less than 325 nsec at the 1.544-mb/s rate and less than 10 µsec at the 50-kb/s rate.

d. The multiplex equipment shall operate as outlined in the requirements for operational systems based on the grade of service for each circuit. (DCAC 300-175-9; app C)

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

94-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope AN/USM-281 or TEK-465.

b. BER test set.

c. Jitter meter.

d. Adapters, cables, connectors, etc., as required.

94-4. TEST PROCEDURES.

a. Complete the top portion of figure 94-1 (DD Form 2096). Enter the input and output test points used and the measured level at the test points. Change SG and GP column headings to read PORT and peak-to-peak phase jitter column heading to read DATA RATE.

b. Connect the test equipment as shown in figure 94-2 and allow approximately 30 minutes for warmup and stabilization. Figure 94-2 contains two different oscilloscope methods with one using a differential amplifier and the other using a dual channel input.

c. Measure the jitter at the receive data channel output or at the MBS inputs and outputs. Normally, during onsite test activities, measure the jitter at the data channel output only.

d. At the transmit end, set the BER test set output data rate to correspond to the channel input data rate. Set the impedance level and signal format to correspond to the test point at which the signal is to be inserted and establish an alternating 1010 pattern from the test set.

e. At the receive end, set the BER test set data rate, impedance, and signal format to correspond to the test point being used and connect the data output of the test set as shown in figure 94-2.

f. If using an oscilloscope with a differential amplifier, proceed as follows:

(1) Connect the oscilloscope differential amplifier to the MBS transmit data.

(2) Connect the oscilloscope dual amplifier to the MBS transmit clock.

(3) Set the oscilloscope differential amplifier for ±DC input at 1 volt per division.

(4) Set the oscilloscope time base to 50 nsec per division. Set the oscilloscope trigger input to DC external. Connect the input to the BER test set trigger.

(5) Set the oscilloscope dual amplifier channel 1 and 2 inputs to DC at 1 volt per division.

NOTE: Ensure that the signal format (NRZ or bipolar) corresponds to the BER test set input/output and the data channel under test.

(6) Adjust the oscilloscope time base/multiplier for a stable pattern and read the jitter on the trailing edge of the pulse as provided by the differential amplifier.

(7) Repeat subparagraphs (1) through (6), above, for the receive data channels by connecting the differential amplifier to the receive data and the dual channel amplifier to the receive clock.

g. At the receive multiplex, connect the receive bipolar or NRZ output to one channel of the dual channel oscilloscope. Connect the BER test set output to one channel of the dual channel oscilloscope and also to the oscilloscope trigger input.

h. Set channel B of the oscilloscope for delayed sweep (at 650 µsec). Set the time division control to 650 µsec and the delay multiplier to 6.5. Set the delayed sweep to the horizontal input display of channel B.

i. Gradually vary the BER test set internal clock control until both patterns are stationary and 4 data bits are displayed.

j. Measure and record the jitter on the trailing edge of one pulse. If required, photograph the jitter and mount the photographs on figure 5-2 (DD Form 2093).

NOTE: If the incoming signal jitters a total of 0.2 cm and the length of one pulse cycle is 10 cm, the peak-to-peak jitter would be:

$$\frac{0.2}{1^0} \times 360^0 = 7.2^0$$

or

$$\frac{0.2}{1^0} \times 647 \text{ nsec} = 12.94 \text{ nsec}$$

k. Repeat subparagraphs a through j, above, for each data channel and timing output having a different data rate. Repeat the procedure for the opposite direction of transmission.

l. Use a jitter test set as a more accurate method of measuring jitter. This test set will measure the jitter on the clock signals when it becomes available. This is the preferred method due to the possible inaccuracies of the preceding tests.

94-5. DATA RECORDING AND ANALYSIS.

a. Complete all applicable blocks of the data sheets. Ensure that all oscilloscope settings and other pertinent data are included on the spectrum photograph data sheet. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

VOICE CHANNEL PHASE JITTER AND PHASE HITS			PAGE _____ OF _____ PAGES DATE	
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

INPUT TEST POINT NO.	OUTPUT TEST POINT NO.	CHANNEL			PEAK-PEAK PHASE JITTER; DEG.	NUMBER OF PHASE HITS (meter method)
		SG	GP	CH		

DD FORM 1 SEP 77 2096

Figure 94-1. System data channel and timing jitter data sheet.

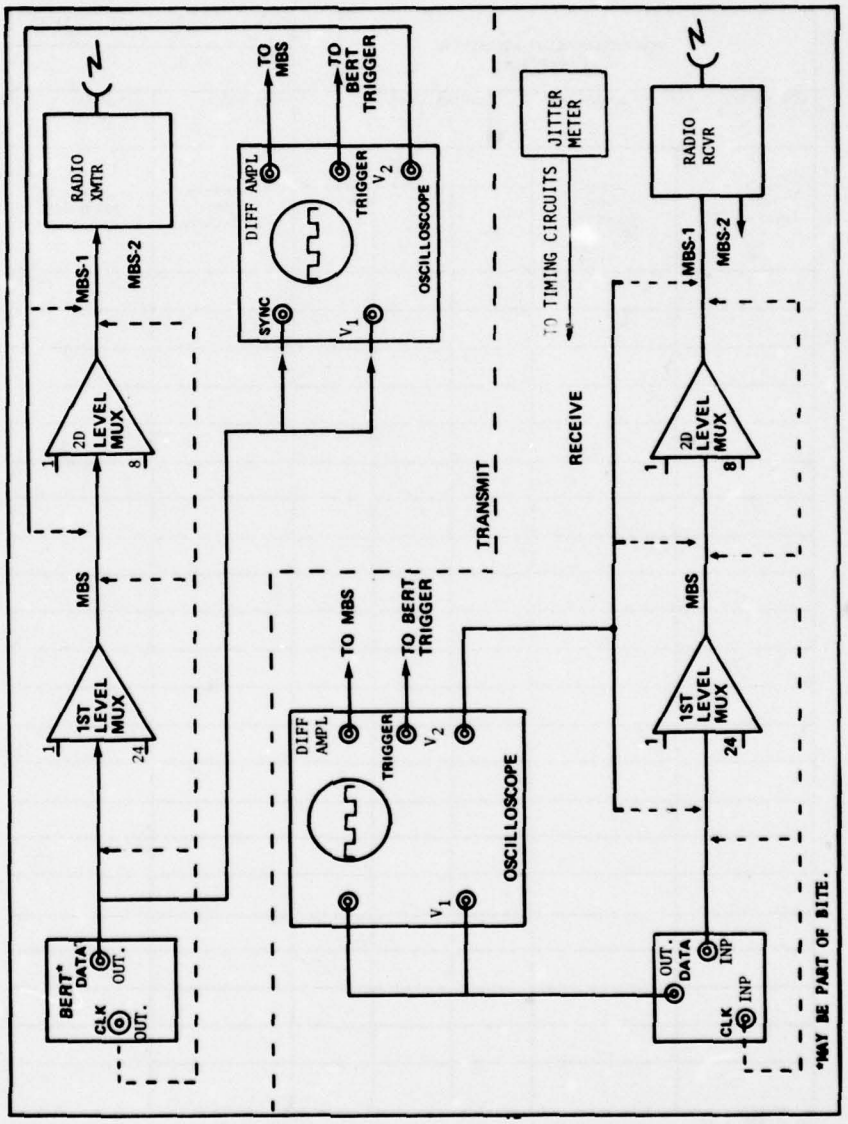


Figure 94-2. System data channel and timing jitter test setup.

CHAPTER 95

MULTIPLEX TRANSMIT TIMING ACCURACY AND STABILITY (DT-292)

95-1. GENERAL.

a. The purpose of this test is to determine the performance characteristics of the digital multiplex transmit timing accuracy and stability.

b. This test is applicable to the TD-1192 (AN/FCC-98) and the TD-1193 multiplex equipment. It may also be performed on the AN/FRC-162 and VICOM 4000-2 system; however, it was not part of the original test and acceptance testing of the equipment in the European area.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

d. This test may be performed on a link or loop basis.

e. During onsite test activities, only a short-term measurement of the timing accuracy and stability is possible since, in most cases, test personnel have no control over the temperature and environmental conditions.

95-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) After the multiplex has been energized for 1 hour at room ambient temperature (25° $\pm 5^{\circ}$C), the initial timing accuracy shall be within $\pm 3 \times 10^{5}$ from that shown in table 95-1.

(2) The frequency of the timing output (table 95-1) of the multiplex terminal when subjected to the full operating temperature range specified in table 95-2 shall not deviate more than $\pm 5 \times 10^{-5}$ from that shown in table 95-1.

(3) The frequency of the multiplex terminal timing output shall not deviate more than $\pm 1 \times 10^{-5}$ per month after the ambient temperature has stabilized ($\pm 2^{\circ}$C) within the range of operating temperatures shown in table 95-2.

b. The following criteria applies to the TD-1193. (CCC-74048)

(1) After the TDM has been energized for 1 hour at room ambient temperature (25° $\pm 5^{\circ}$C), the frequency of the timing output shall be within 3×10^{5} from the nominal timing rates specified in tables 92-1 and 95-3.

(2) The frequency of the timing output of the TDM when subjected to the full operating temperature range specified in table 95-2 shall not deviate more than $\pm 5 \times 10^{5}$ from the nominal timing rates contained in tables 92-1 and 95-3.

Table 95-1. TD-1192 (AN/FCC-98) Timing and Signal Characteristics

MULTIPLEX OUTPUT AND DEMULTIPLEX DATA AND TIMING PULSE CHARACTERISTICS	CHANNEL VERSION MODE OF OPERATION NUMBER OF CHANNELS				24-CHANNEL VERSION MODE OF OPERATION
	3	6	12	24	
Data bit rate (kb/s)	192	384	768	1.544	1.544
Nominal data unit interval (μsec)	5.208	2.604	1.302	0.648	0.648
Timing frequency (kHz)	192	384	768	1.544	1.544
Nominal timing interval (μsec) transition-to-transition	2.604	1.302	0.651	0.324	0.324
Signal format	NRZ				NRZ and bipolar

Table 95-2. TD-1192 (AN/FCC-98) Environmental Operating Parameters*

PARAMETER	OPERATING	NONOPERATING
Temperature (°C)	0 to 49	-40 to 68
Relative humidity (%)	Up to 95	Up to 95
Altitude (ft, MSL)	Up to 15,000	--

*The multiplex terminal shall operate continuously and meet all performance requirements when subjected to environmental conditions within the operating ranges specified in the table. After storage in the environmental nonoperating ranges specified in the table, the terminal shall meet the established performance.

(2) The frequency of the timing output of the TDM when subjected to the full operating temperature range specified in table 95-2 shall not deviate more than $\pm 5 \times 10^{5}$ from the nominal timing rates contained in tables 92-1 and 95-3.

(3) The frequency of the timing output of the TDM shall not deviate from the nominal timing rates contained in tables 92-1 and 95-3 by more than $\pm 1 \times 10^{5}$ per month after the ambient temperature has stabilized (±2°) within the range of operating temperatures contained in table 95-2

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

95-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter.

b. Digital printer.

c. Digital-to-analog converter.

d. Stripchart recorder.

e. Programmable calculator.

f. Temperature sensor and converter.

g. Humidity sensor and converter.

h. Adapters, connectors, cables, etc., as required.

Table 95-3. TD-1193, TDM MBS Characteristics

NUMBER OF 1.544 mb/s PORTS	NOMINAL TIMING RATE (MHz)	NOMINAL DATA RATE (mb/s)	NOMINAL DATA UNIT INTERVAL (µsec)	NOMINAL TIMING PULSE WIDTH (µsec)	TIMING SIGNAL FORMAT	DATA SIGNAL FORMAT
2	3.232	3.232	0.3094	0.1547	Polar square wave	NRZ
4	6.464	6.464	0.1547	0.0774		
6	9.696	9.696	0.1031	0.0516		
8	12.928	12.928	0.0774	0.0387		

95-4. TEST PROCEDURES.

a. General.

(1) The four basic techniques for measuring the frequency accuracy and stability of the multiplex equipment timing are:

(a) Taking spot measurements with a frequency counter and manually recording the readings after which the readings are averaged to arrive at a median value.

(b) Recording the readings with a digital printer connected to the frequency counter and manually averaging the individual readings to arrive at a median value.

(c) Recording and storing the discrete readings in a programmable calculator with the calculator automatically providing the median value for all test samples as well as the percentage of accuracy.

(d) Converting the frequency counter digital output to an analog or DC signal and recording any variations from the specified frequency over a specified time frame.

(2) The method used will depend on the availability of test equipment and the stipulated requirements. Any of the above techniques may be used and will depend on the degree of accuracy required from the test results.

(3) During onsite test activities, the spot measurements or recorded averaging techniques will be used since control of the temperature and humidity is not feasible. If required, repeat the test for receive timing of the unit under test. When the unit is removed from the environmental chamber, perform a BER test as outlined in DT-285 through DT-290, as applicable.

b. Spot Measurement.

(1) Connect the test equipment as shown in figure 95-1, as applicable, and allow approximately 30 minutes for warmup and stabilization.

(2) Verify the performance of the frequency counter by performing the self-check calibration contained in the operating instructions with the instrument.

(3) Connect the frequency counter input to the multiplex clock output connector. If an external clock output connector is not available, the counter may be connected to the master oscillator test point; however, caution must be observed to ensure that the clock is not loaded by the counter. On the TD-1192 (AN/FCC-98), the frequency counter may also be connected at TP-1 (MBS clock) of the transmit interface unit.

(4) Connect the digital printer to the frequency counter ouput as shown in figure 95-1, if used.

(5) Measure the frequency of the transmit master oscillator for a period of 5 minutes in 1-minute intervals. Record the number of samples taken, the sample average, and the frequency accuracy on figure 56-2 (USACC Form 653-R).

(6) If testing the unit at the various data rates as shown in tables 92-1, 95-2, and 95-3, repeat subparagraphs (1) through (4), above, for each data rate.

(7) Compute the frequency tolerance for each data rate and compare the computed value to the measured test results. Record the results on the data sheet.

NOTE: An example of short-term tolerance based on equipment acceptance is shown below:

TD-1192 (AN/FCC-98)

24 channels	±23.16 Hz
12 channels	±11.52 Hz
6 channels	±5.76 Hz
3 channels	±2.88 Hz

TD-1193

Two 1.544 ports	±48.48 Hz
Four 1.544 port strapped	±96.96 Hz
Six 1.544 ports strapped	±145.04 Hz
Eight 1.544 ports strapped	±193.92 Hz

(8) If the test is to be performed at the receive end, connect the frequency counter to the receive external timing connector and repeat subparagraphs (2) through (8), above.

c. Long-Term Frequency Accuracy and Stability at Ambient Environmental Conditions. Precise long-term accuracy and stability measurements are not normally feasible during onsite field testing; however, they can be performed under existing environmental conditions.

(1) Connect the frequency counter to the multiplex timing output connector as shown in figure 95-1.

(2) Calibrate the chart recorder channel that will be used for the frequency accuracy and stability over the expected range of frequency change, humidity, and temperature variations. The frequency accuracy and stability (long-term) of the multiplex is $\pm 1 \times 10^{-5}$ from the nominal frequencies shown in tables 95-1, 92-1, and 95-3.

NOTE: The sensors shown in figure 95-1 are normally a part of the environmental chamber used for inplant testing and may not be available for onsite testing.

(3) Record the multiplex master clock frequency for 30 days or as directed. Divide the stripchart recording into 1-hour intervals and determine the average frequency, temperature, and humidity for each hour.

(4) Use multiple channel stripchart recordings or automatic recording and computing equipment to record data in this part of the test. These recordings will provide simultaneous, time-correlated variations in the recorded parameters. From the long-term recordings, determine the median value of each parameter as follows:

(a) Divide the recording into equal time intervals. If testing the equipment to the requirements of paragraph 95-2, the recording should be divided into 1-hour intervals.

(b) Determine the value of each interval. Determine the median for the short-term interval by use of a stretched string or other means to estimate the value or sample the interval taking the instantaneous value of the parameters at each time interval. Either will result in approximately the same long-term median; however, there will be a difference in the cumulative distribution. The sample method will result in a wider range of values than the interval median method; therefore, annotate the technique used on figure 29-3 (DD Form 2098).

(c) Determine the long-term median for each recorded parameter. Arrange the values in ascending or descending order in column 2 of figure 29-3 (DD Form 2098). Make a stroke for each interval at each of the values. Count the total number of intervals (or strokes) and divide this total by 2. Starting at either top or bottom of the column, count the number of strokes equal to this quotient. The value corresponding to that point is the long-term median.

(d) Determine the distribution and cumulative distribution by calculating the values on the data sheet. If directed, plot the cumulative distribution for each parameter on figure 29-5 (DCA Form (Test) T1-14).

d. Testing Under Environmentally Controlled Conditions.

(1) Place the unit to be tested into the environmental chamber and connect the equipment as shown in figure 95-1 with all power applied and the unit ready for operation.

(2) With the unit operating, raise the internal chamber temperature to 49 degrees Centigrade (120.20 degrees Fahrenheit).

(3) Maintain the temperature at 49 degrees Centigrade for a period of not less than 24 hours.

NOTE: At each change of temperature and humidity, annotate the time and chamber temperature on the recording.

(4) Reduce the chamber temperature to 0 degree Centigrade (32 degrees Fahrenheit). The rate of change should not exceed 2 degrees Centigrade per minute.

(5) Maintain the chamber temperature a 0 degree Centigrade for a period of not less than 24 hours.

(6) Raise the chamber temperature to 49 degrees Centigrade while maintaining a relative humidity of 30 percent.

(7) Increase the chamber humidity to 95 percent for a 4-hour period at a temperature of 49 degrees Centigrade.

(8) Reduce the chamber temperature to 0 degree Centigrade over a 12-hour period at 95-percent relative humidity.

(9) Reduce the chamber humidity to 30 percent and increase the chamber temperature by 2 degrees Centigrade (35.60 degrees Fahrenheit) each hour until the temperature has stabilized at 95 degrees Fahrenheit.

(10) Alternately increase and decrease the temperature and humidity in steps as directed while recording the master oscillator output frequency for a 30-day period. At each change of temperature or humidity, record the applicable information on the data sheet.

(11) If the above steps conflict with initial equipment inplant testing, use the inplant test sequence.

(12) From the 30-day test data, record the long-term stability on the data sheet and compare the results with the requirements of paragraph 95-2, above.

e. Timing Accuracy and Stability Testing Using a Programmable Calculator. Connect the unit to be tested to a programmable calculator as shown in figure

95-1. If more than one parameter is to be recorded, an interface bus should be used between the calculator and the device under test. The calculator must be programed to provide the following essential information:

(1) Number of samples taken during the test period.

(2) Average frequency measured during each sample.

(3) The lowest and highest frequency measured during the sample period.

(4) Stability over the entire test period.

(5) Temperature and humidity at which the samples were taken.

(6) A plot of the frequency stability versus temperature and humidity.

95-5. DATA RECORDING AND ANALYSIS.

a. Review all data for accuracy and compliance with specified performance requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

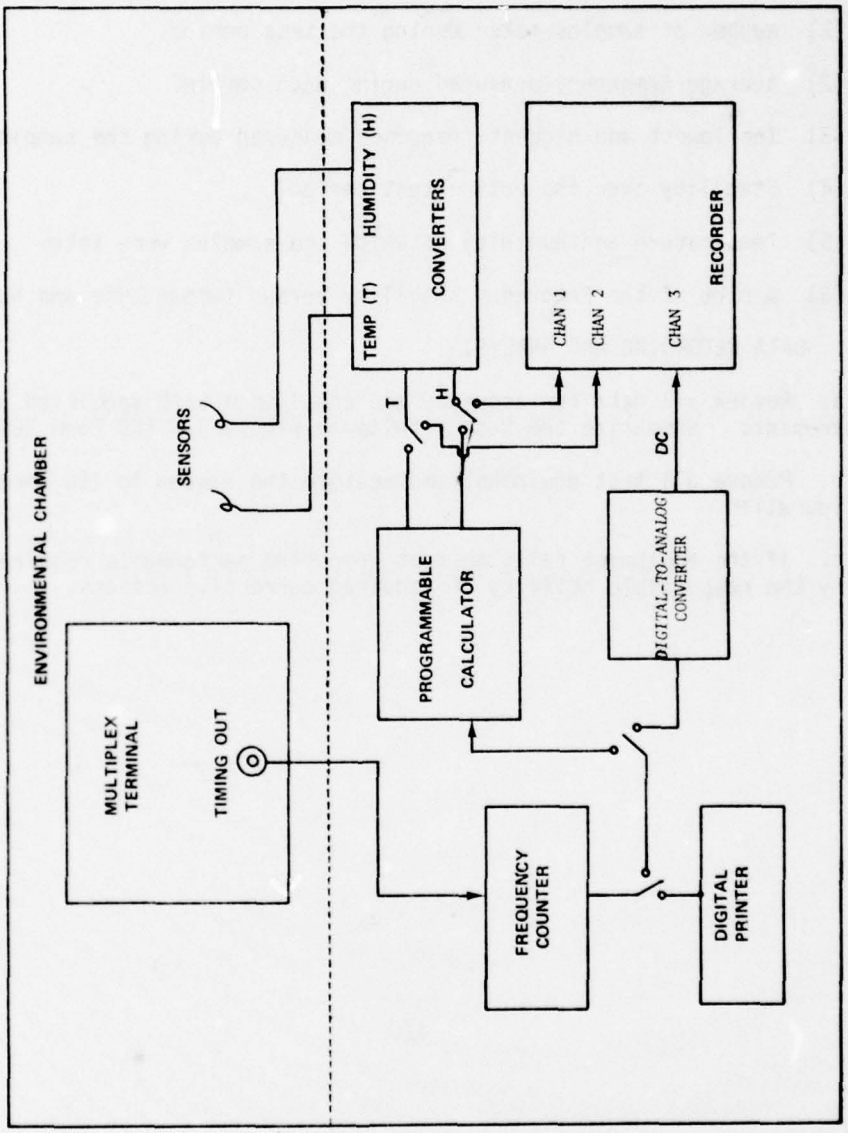


Figure 95-1. Multiplex transmit timing accuracy and stability test setup.

CHAPTER 96

BIPOLAR AND NRZ DATA CHANNEL PORT INPUT AND OUTPUT IMPEDANCES (DT-293)

96-1. GENERAL.

a. The purpose of this test is to measure the bipolar and NRZ data channel port input and output impedances.

b. Procedures for measuring the voice frequency channel input and output impedances are contained in DT-278 and DT-279.

c. Impedance measurements are normally a part of equipment performance testing during initial equipment acceptance from the manufacturer. Therefore, the impedance of the equipment is primarily a design function and should not be required during routine onsite testing. It may be necessary, however, to perform the test as a diagnostic routine when other test data indicates a discontinuity.

d. When performed, the test should be conducted directly at the equipment input/output terminals to minimize any effects that external equipment may have on the test results.

e. This test may be performed on contractor EF&I equipment to ensure that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite testing as directed.

96-2. SPECIFICATIONS.

a. TD-1192 (AN/FCC-98). (CCC-74047)

(1) *Output impedance.*

(a) The bipolar line impedance shall be 100 ohms nominal (balanced).

(b) The impedance for NRZ outputs and square wave timing outputs shall be 78 ohms ±10 percent (balanced) except for the 0- to 20-kb/s asynchronous data channel output which shall be 135 ohms ±10 percent (balanced).

(2) *Input impedance.*

(a) The input impedance for the bipolar input shall be 100 ohms nominal (balanced).

(b) The input impedance for NRZ data inputs and square wave timing inputs shall be 78 ohms ±10 percent (balanced), except for the 0- to 20 kb/s asynchronous data channel input which shall be 135 ohms ±10 percent (balanced).

b. TD-1193. (CCC-74048)

(1) Output impedance.

(a) The bipolar output impedance shall be 100 ohms ±10 percent (balanced).

(b) The impedance for NRZ data outputs and square wave timing outputs shall be 78 ohms ±10 percent (balanced).

(2) Input impedance.

(a) The bipolar input impedance shall be 100 ohms ±10 percent (balanced).

(b) The input impedance for NRZ data inputs and square wave timing inputs shall be 78 ohms ±10 percent (balanced).

c. AN/FRC-162 and VICOM 4000-2 System. The multiplex input/output for the bipolar/NRZ signal is a nominal 75 ohms (unbalanced) or 100 ohms (balanced) depending on options installed. Refer to the equipment manual and installation configuration.

96-3. TEST EQUIPMENT REQUIRED.

a. Wideband oscillator.

b. True RMS voltmeter.

c. Oscilloscope.

d. BER test set.

e. Impedance bridge.

f. RF voltmeter.

g. Precision resistors, as required.

96-4. TEST PROCEDURES.

a. General.

(1) There are a number of different ways to measure the input and output impedances of a device and in most cases, each method may yield slightly different results. Therefore, if trying to duplicate original test results, the same setup and procedures should be used. Some of the methods that may be used are:

(a) Direct comparison.

(b) Bridge method.

(c) Vector voltmeter or oscilloscope.

The method to be used will depend on the test equipment availability stipulated requirements, or as directed by the team chief or onsite NCOIC.

(2) Repeat the appliable procedure for each data input/output, and the transmit and receive input/output clock circuits.

b. Direct Comparison Method.

(1) Connect the test equipment as shown in figure 96-1a and allow approximately 30 minutes for warmup and stabilization.

(2) Set the oscillator output frequency and level to correspond to the equipment data rate and level at which the measurement is to be performed. To ensure that the oscillator output impedance (R_0) equals the impedance of the test point to be measured, measure the oscillator open circuit voltage (V_2). Connect a precision resistor (equal to the test point to be measured) across the oscillator output and measure the terminted voltage (V_1). If the oscillator output impedance matches the load, V_2/V_1 should equal 2. If V_2/V_1 does not equal 2, calculate the oscillator output impedance (R_0) from:

$$R_0 = \frac{V_2 - V_1}{V_1} \times (\text{ohms of termination used})$$

(3) Connect the oscillator to the equipment under test as shown in figure 96-1b. Do not readjust the oscillator frequency or level as established in subparagraph (2), above.

(4) Measure the oscillator output voltage (V_1) and calculate the equipment input impedance using the open circuit voltage established in subparagraph (2), above, and the terminated voltage from:

$$\text{Terminal impedance} = \frac{V_1}{V_2 - V_1} \times R_0 \text{ ohms}$$

(5) Record the results on figure 96-2 (USACC Form 667-R).

(6) Repeat the above procedures for the equipment output (receive) terminals.

NOTE: Ensure that there are no data signals or other output voltages at the output test point that would invalidate the measurements.

c. Bridge Method.

(1) Connect the test equipment as shown in figure 96-3.

(2) Set the output frequency and level to correspond to the equipment data rate and level of the test point being used. As an example, in measuring the 1.544-mb/s port, the generator (bridge) would be set to 1.5 MHz.

(3) Calibrate the bridge in accordance with the manufacturer's instructions with the output terminated into a precision resistor equal to the test point impedance to be measured.

(4) After the bridge has been calibrated, remove the termination end connect it to the equipment to be tested without changing the frequency or level.

(5) Set the impedance bridge for a precise balance. Read and record the measured impedance.

d. Oscilloscope Method (Bipolar or NRZ Input).

(1) Connect the test equipment as shown in figure 96-4.

(2) Set the oscilloscope time base to 50 nsec per division (depending on the rate of data signal) and set the unit for external DC trigger.

(3) Connect the oscilloscope trigger to the clock output of the BER test set or to the equipment external clock output connector.

(4) Set the BER test set to the applicable bit rate of the equipment under test and the format to bipolar or NRZ as applicable.

(5) Set the BER test set to provide all 1's to the digital input of the equipment or the precision load if performing a calibration.

(6) Connect the oscilloscope differential amplifier input to the data input of the test point being used. Position the oscilloscope trace to the center horizontal reference line.

(7) Set the oscilloscope differential amplifier for positive (+) DC input (V_C) polarity.

(8) Disconnect the oscilloscope V_C input from the precision terminating resistor or the data circuit input. Adjust the oscilloscope V_C control to position the positive going logic 1 to the reference line.

(9) Read and record the (V_C) open circuit voltage.

(10) Set the oscilloscope differential amplifier for negative (-) input polarity.

(11) Connect the differential amplifier to the input test point. Adjust the oscilloscope V_C control to position the logic 1 to the reference line. The input port or channel should be in the normal operating mode to provide the appropriate termination.

(12) Read the terminated V_C voltage as read on the oscilloscope. Calculate the impedance from the open circuit (V_C) and terminated voltage as outlined in paragraph 96-4b(4), above. Record the impedance on the data sheet.

e. Oscilloscope Method (Bipolar or NRZ Output).

(1) Set the BER test set to provide the required data rates and clock of the digital test point to be used (fig. 96-4). Set the signal format to correspond to the unit input/output format (NRZ or bipolar).

(2) Set the BER test set to provide all 1's to the test point being used. Set the oscilloscope differential amplifier for 1 volt per divisiom and positive (+) DC input. Set the time base for 1 µsec per division and external trigger.

(3) Connect the oscilloscope differential amplifier to the data output test point and position the oscilloscope trace to the center horizontal line.

(4) Set the oscilloscope differential amplifier for positive (+) DC input (V_C polarity) at 1 volt per division.

(5) Adjust the oscilloscope V_C control to place a positive going logic 1 of the signal on the reference line. Read and record the V_C voltage on the oscilloscope. Use the delay control of the differential amplifier to locate and provide a stable pattern.

(6) Set the oscilloscope differential amplifier for negative (-) DC input and set the BER test set to provide an alternating 1010 pattern. Adjust the oscilloscope V_C control to display a negative going logic 1 on the reference line. Read and record the V_C voltage.

(7) Disconnect the BER test set input from the test point and read the open circuit (V_C) voltage.

(8) Calculate the terminal impedance from the open circuit voltage and terminated voltage. Record the results on the data sheet.

(9) For those terminals configured for NRZ operation, perform the following:

(a) Set the BER test set to provide an alternating 1010 pattern.

(b) Adjust the oscilloscope differential amplifier (V_C) to place a logic 1 from the pattern generator on the reference line. Read and record the V_C voltage. Use the delay control of the oscilloscope to provide a stable pattern.

(c) Set the oscilloscope differential amplifier for a positive (+) DC input.

(d) Adjust the oscilloscope V_C control to place a logic 0 on the reference line.

(e) Measure the open circuit voltage and terminated voltage (V_c) and calculate the impedance as outlined in paragraph 96-4b, above. Record the results on the data sheet.

96-5. DATA RECORDING AND ANALYSIS.

a. Review all data for accuracy and compliance with specified performance levels. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

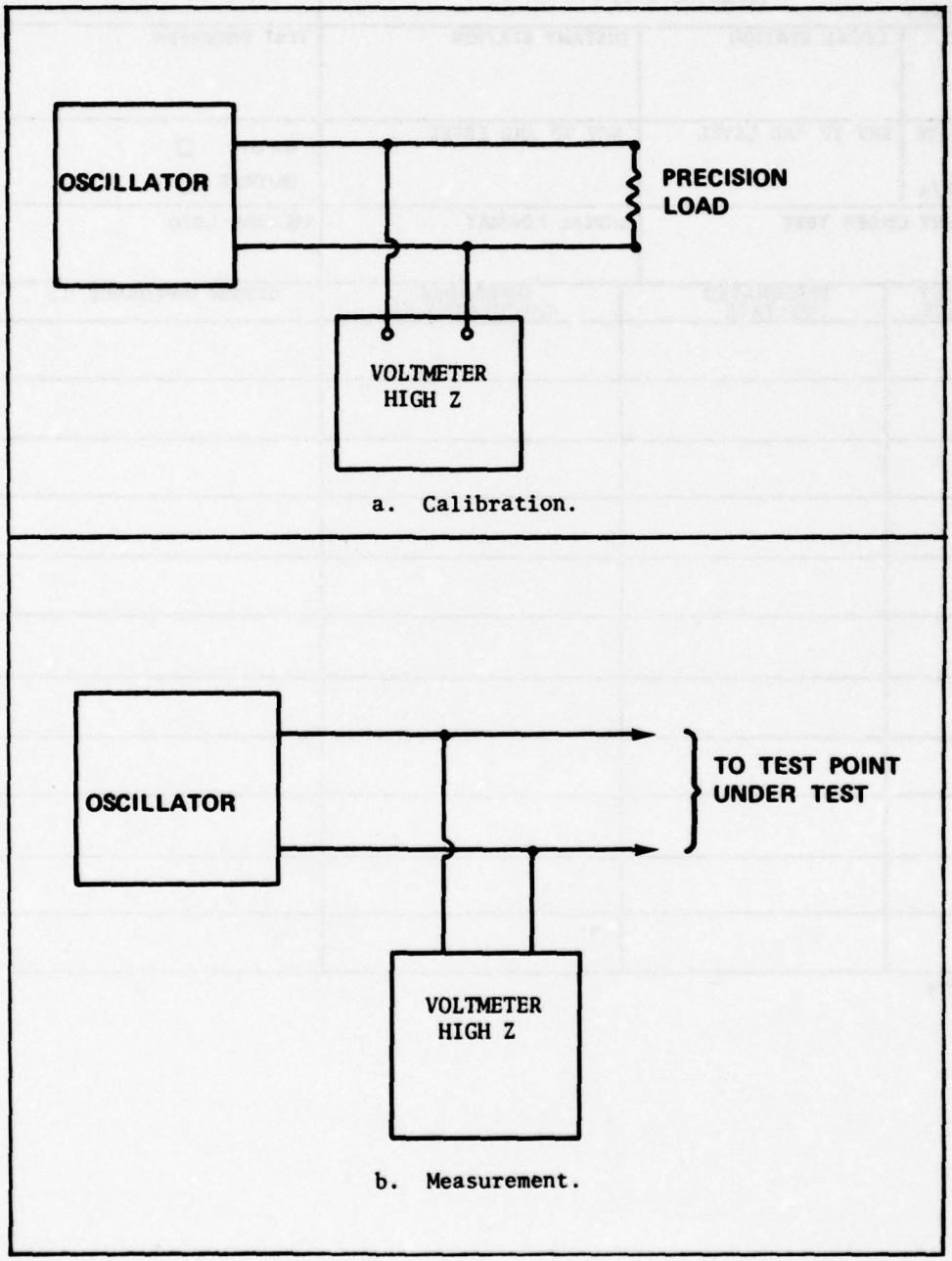


Figure 96-1. Bipolar and NRZ data channel port input/output impedances (comparison method) test setup.

MULTIPLEX INPUT/OUTPUT IMPEDANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
DATA RATE mb/s	XMT TP AND LEVEL	RCV TP AND LEVEL	INPUT ☐ OUTPUT ☐
EQUIPMENT UNDER TEST		SIGNAL FORMAT	METHOD USED

OPEN CKT VOLTAGE	TERMINATED VOLTAGE	IMPEDANCE CALCULATED (Ω)	DESIGN IMPEDANCE (Ω)

COMMENTS

USACC FORM 667-R
1 MAY 79

Figure 96-2. Multiplex input/output impedance data sheet.

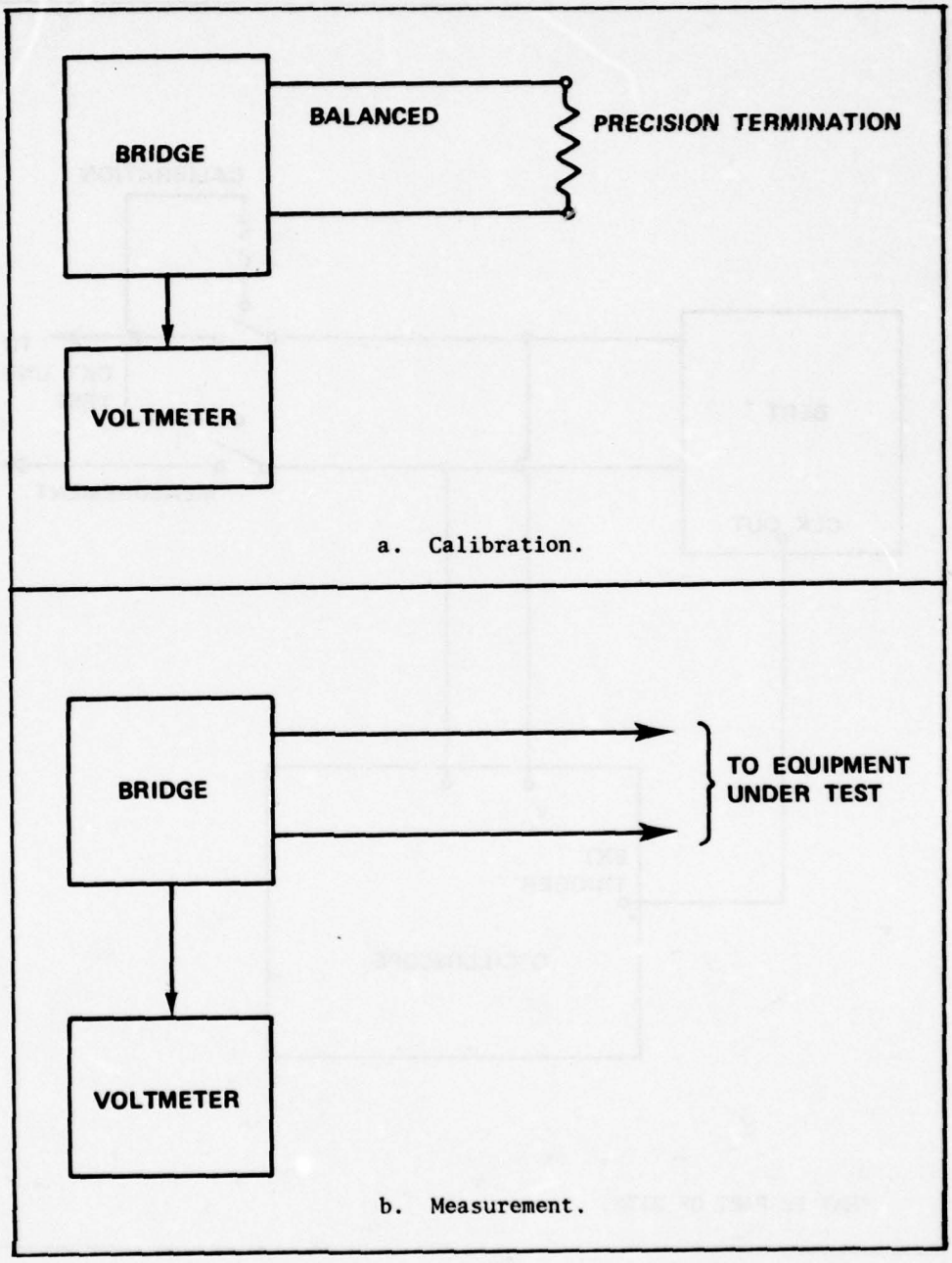


Figure 96-3. Bipolar and NRZ data channel port input/output impedances (bridge method) test setup.

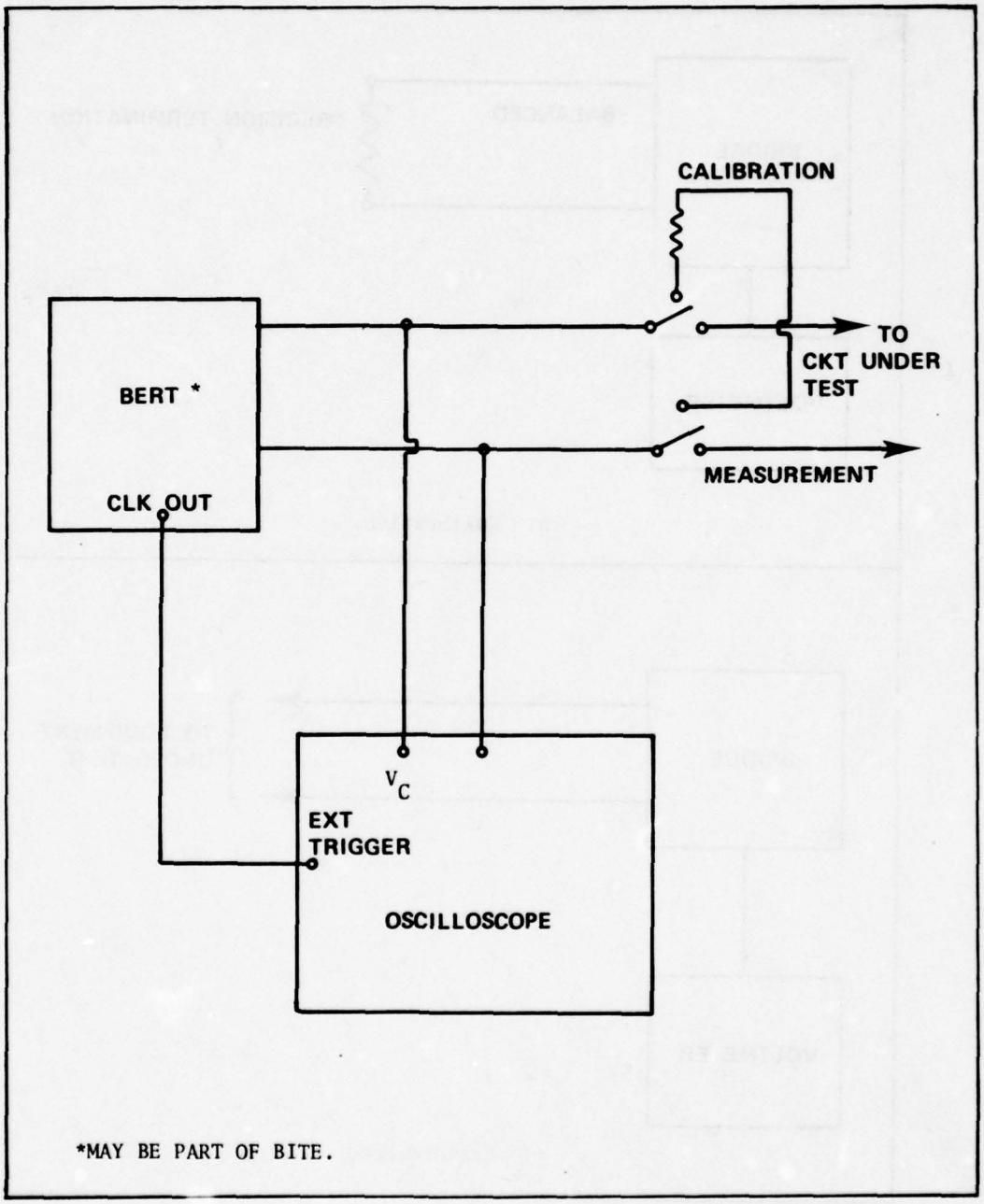


Figure 96-4. Bipolar and NRZ data channel port input/output impedances (oscilloscope method) test setup.

CHAPTER 97

MULTIPLEX INPUT/OUTPUT VOLTAGE LEVELS (DT-294)

97-1. GENERAL.

a. The purpose of this test is to measure and demonstrate the input and output digital multiplex voltage levels.

b. This test may be performed at the digital equipment patch panel or directly at the input/output terminals of the equipment.

c. During onsite test activities, the levels specified in paragraph 97-2 should be verified; however, it is not necessary to vary the input and output voltage levels during normal onsite testing since this would be a design verification test.

d. During the test, observe the input and output impedances and signal format of the equipment under test as shown in paragraph 97-2 and the equipment technical manual.

e. This test may be performed on contractor EF&I systems to ensure that they meet specified performance criteria. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

97-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) *Input voltage level.* At the NRZ digital inputs, voltage levels from ±0.2 to 7.0 and from -0.2 to -7.0 volts shall be properly detected and processed without adjustment. At the bipolar digital inputs, voltage levels from ±1.5 to ±3.3 volts shall be properly detected and processed without adjustment.

(2) *Output voltage level.* For NRZ data and square wave timing, a positive voltage is a logic 1 and a negative voltage is a logic 0. The open circuit voltage at the NRZ data outputs and square wave timing outputs when terminated in their characteristic impedance shall be from ±3 to ±0.5 volts. For the bipolar signal, the output voltage shall be as specified for the D3 channel bank as shown in DT-277.

b. The following criteria applies to the TD-1193. (CCC-74048)

(1) *Input voltage level.* At the NRZ digital inputs, voltage levels from 0.2 to 7.0 and from -0.2 to -7.0 shall be properly detected and processed without adjustment. At the bipolar digital inputs, voltages levels from ±1.5 to ±3.3 shall be properly detected and processed without adjustment.

(2) *Output voltage level.* Low speed is defined as data and clock rates below 2 mb/s and 2 MHz, respectively. High speed is defined as data and clock rates above 2 mb/s and 2 MHz, respectively.

(a) *Low speed output voltage.* For NRZ data and timing, a positive voltage is a logic 1 and a negative voltage is a logic 0. The open circuit voltage at the digital output shall be ±6±1 volts. When terminated in 78 ohms ±10 percent, it shall be ±3±0.5 volts. For the bipolar signal, the open circuit voltage for a logic 1 shall be ±6±0.6 volts, and for a logic 0 shall be 0±0.01 volt. When terminated in 100 ohms ±10 percent, the voltage level for a logic 1 shall be ±3±0.3 volts, and for a logic 0 shall be 0±0.005 volt.

(b) *High speed output voltage level.* For NRZ data and timing, the open circuit voltage at the digital output shall be ±4±0.4 volts. When terminated in 78 ohms ±10 percent it shall be ±2±0.2 volts.

c. The following cirteria applies to the AN/FRC-162 and VICOM 4000-2 system.

(1) The output shall be adjustable from 0.5 to 1.0 VPP.

(2) The input shall be 1±0.5 volt at 75 ohms.

d. The multiplex shall operate as specified in the standard engineering plan or contract specifications.

97-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Oscilloscope.

c. Precision terminations, as required.

97-4. TEST PROCEDURES.

a. General.

(1) Connect the test equipment as shown in figure 97-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Initially adjust the digital input and output levels for a 1-VPP signal as measured with the oscilloscope.

(3) If performing the test as part of the equipment performance limits, perform a back-to-back patch at the bipolar or NRZ output and input as shown in figure 97-1.

(4) Repeat the test for each input and output at both terminals. Record the results on figure 97-2 (USACC Form 668-R).

b. TD-1192 (AN/FCC-98). (CCC-74047)

(1) Connect the bipolar multiplexer output to the bipolar demultiplexer input with a video patch cable at the PCM access unit.

(2) Connect the BER test set to the digital channel under test. Set the data and clock rates to correspond to the equipment input clock and data rates.

(3) Set the transmit BER test set for a 1-VPP data signal.

(4) With the multiplex in a local loop, transmit an alternating 1010 pattern for at least 2047 bits. Observe that the received error rate equals or exceeds $1x10^{-7}$.

(5) At the transmit multiplex, reduce the digital output of the BER test set to -1.5 volts and repeat subparagraph (4), above. Decrease the BER test set output to -3.3 volts and repeat subparagraph (4), above.

(6) Repeat subparagraphs (4) and (5), above, at 1.5 and 3.3 volts. There should be no degradation of the error rate over that established in subparagraph (4), above.

(7) At the receive end, connect the oscilloscope input to the receive data channel output and measure the bipolar open circuit voltage. Record this value on the data sheet. The open circuit voltage should be ±6±0.6 VDC. Terminate the output with a resistor equal to the output impedance. Measure and record the terminated circuit voltage on the data sheet.

(8) For the NRZ digital inputs, connect the test equipment as shown in figure 97-1 and proceed as follows:

(a) Connect the BER test set to the applicable test point. Set the BER test set for NRZ format at a level of 1 VPP.

(b) At the receive end, connect the error detector (part of the test set) to the test point of the equipment under test.

(c) At the transmit end, transmit data for approximately 1 minute or for at least 2047 bits. The BER test set should be set to provide an alternating pattern of 1010.

(d) At the receive end, verify that the BER does not exceed $1x10^{-7}$ if performed in a multiplex loopback.

(e) At the transmit end, set the BER test set output to -0.2 volt and repeat subparagraphs (c) and (d), above. Change the BER test set input to -7.0 volts and then to 7.0 volts and repeat subparagraphs (c) and (d), above.

(f) At the receive end, adjust the oscilloscope to view the transmitted 1010 pattern and measure the open circuit voltage of the logic 1. Terminate

the multiplex output into its characteristic impedance and measure the terminated circuit voltage. The open circuit voltage should be ±6±0.6 VDC.

(g) Set the oscilloscope to measure a logic 0 unterminated and then terminate the output into its characteristic impedance. Record the results on the data sheet.

c. TD-1193 and AN/FRC-162 and VICOM 4000-2 System. (CCC-74048 for TD-1193) The measurement techniques for this equipment are the same as described in subpararaph b, above, the only exception being the difference in voltage levels, impedance, and BER requirements. In this equipment measure:

(1) BER to establish the equipment performance.

(2) The input voltage levels changing the levels while observing the BER performance.

(3) The output open circuit voltage and the voltage of each channel or port when the output is terminated into its characteristic impedance.

97-5. DATA RECORDING AND ANALYSIS.

a. Review all test results for completeness and compliance with the stated requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

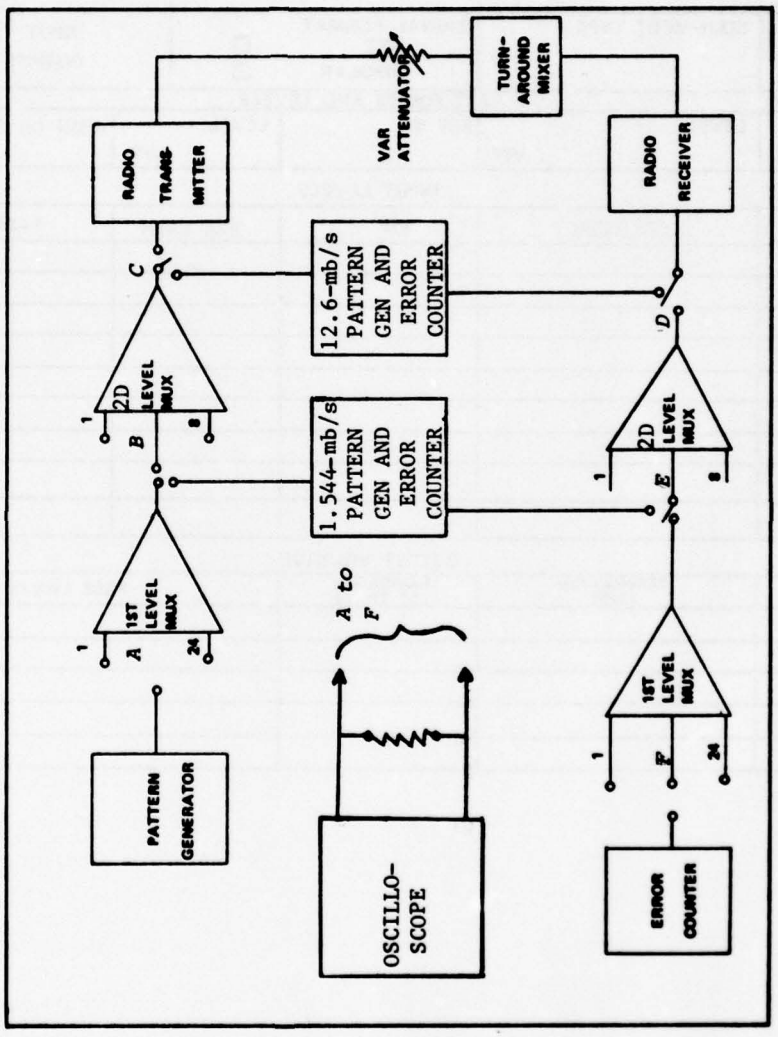


Figure 97-1. Multiplex input/output voltage levels test setup.

MULTIPLEX INPUT/OUTPUT VOLTAGE AND PERFORMANCE LEVEL (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
DATA RATE	EQUIPMENT TYPE	SIGNAL FORMAT NRZ ☐ BIPOLAR ☐	INPUT ☐ OUTPUT ☐

TEST POINTS AND LEVELS				
XMT TP	LEVEL VPP	RCV TP	LEVEL VPP	CHAN OR PORT NO.

INPUT LEVELS				
VPP	BER PRFM	VPP	BER PRFM	PASS LIMITS
+ 0.2				
+ 7.0				
− 0.2				
− 7.0				
± 1.5				
± 3.3				
1.0				

OUTPUT VOLTAGE			
OPEN CKT (VPP)	TERMINATED (VPP)	IMPEDANCE AT TP (Ω)	PASS LIMITS

COMMENTS

USACC FORM 668-R
1 MAY 79

Figure 97-2. Multiplex input/output voltage and performance level data sheet

CHAPTER 98

CODER/DECODER (DT-295)

98-1. GENERAL.

a. The purpose of this test is to determine the code format, code levels, and stability of the encoding and decoding circuits of the digital multiplex. This test verifies the capability of the coder and decoder to perform signal compression and expansion at the input and output levels (DT-294).

b. This is primarily a design verification test and may not be routinely performed during onsite testing. If the S/Nq results are satisfactory during DT-276, the coding and decoding circuits should be performing satisfactorily.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance limits. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

98-2. SPECIFICATIONS.

a. The following criteria applies to the TDM/PCM equipment. (MIL-STD-188-100)

(1) Each nominal 4-kHz channel of a long haul or of a tactical TDM/PCM reference voice bandwidth link shall be sampled at a nominal rate of 8,000 samples per second.

(2) Each sample from a nominal 4-kHz audio channel shall be encoded into an 8-bit folded binary code word with the most significant bit transmitted first.

(3) The compander compressor shall have a 15-segment characteristic with the input step size on each segment twice that of the segment next closest to the center of the range. The expander shall have the complementary transfer characteristics of the compressor.

b. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) Format. The channel information format shall consist of 8 consecutive bits forming a PCM word which represents the quantized amplitude of the sample taken of that particular channel. Each frame shall have a period of 125 µsec (equivalent to an 8000-Hz channel sampling rate).

(2) Compressor/coder characteristics, analog-to-digital conversion. The compressor/coder shall have a 15-segment characteristic with the input step size of each segment twice that of the segment next closest to the center range as shown in figure 98-1. The compressor/coder shall be fully modulated throughout its full range of 256 levels by a test tone level of +3 dBm0 applied to the audio input of the multiplexer.

(3) *Code type and levels.* An 8-digit folded binary code shall be used with the most significant bit transmitted first. The input signal shall be quantized into one of 256 possible amplitude levels. The folded binary code structure is shown in table 98-1. The all zero word which represents the most negative voltage (binary notation 00000000) shall be suppressed.

(4) *Code level stability.* The nominal code level corresponding to zero modulation (input terminated) of a channel shall be midway between levels 127 and 128, and shall not vary more than ±7 levels under all operating conditions. The channel-to-channel variation of code centering at zero modulation shall not exceed ±5 levels under all operating conditions.

(5) *Encoder/decoder.* The expander/decoder shall convert the received PCM signal to an analog signal. The expander/decoder shall have complementary transfer characteristics of the compressor/coder.

c. The criteria for the AN/FRC-162 and VICOM 4000-2 system is essentially the same as for the TD-1192 (AN/FCC-98).

d. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

98-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. Oscillator.

c. Digital voltmeter.

d. Cables and connectors, as required.

98-4. TEST PROCEDURES.

a. Format.

(1) Connect the test equipment as shown in figure 98-2 and allow approximately 30 minutes for warmup and stabilizaton.

(2) Set the multiplex equipment for 24-channel NRZ operation and if the equipment is not in operation, terminate all voice frequency channels into 600 ohms. Operate all voice frequency channel busy switches to the busy position.

(3) Set the oscillator to 1020 Hz at 0 dBm0 and connect the oscillator to the voice frequency channel to be used for the test.

(4) Set the oscilloscope dual amplifier channel 1 input to observe the receive signal frame and set the oscilloscope time base for 2 µsec per division. Set the dual amplifier to trigger on the channel 1 input.

(5) Connect the oscilloscope main trigger input to the channel synchronization test point of the common unit.

(6) Connect the oscilloscope dual amplifier to the channel input to the signal test point of the receive common unit.

(7) Note on the oscilloscope the format length for the channel under test and record this data on figure 98-3 (USACC Form 669-R).

(8) Momentarily disconnect the oscillator output from the channel under test with switch S1. Observe three bytes on the oscilloscope of the channel under test.

(9) Momentarily close and open switch S1 while observing the channel under test.

(10) Verify that the center 8 bits on the oscilloscope (byte for channel under test) change and that the lower and upper 8 bits remain at constant ±7 levels.

(11) Verify from the oscilloscope that the interval for the center 8 bits is 5.185 µsec.

b. Code Type and Level.

(1) Connect the test equipment as shown in figure 98-4. If test points are available or the coder/decoder module can be placed on an extender board, use a DC supply to simulate the various input levels to the coder/decoder.

(2) Connect the digital voltmeter to the coder input and adjust the coder input DC level to correspond to a +3 dBm0 input at the channel level. Adjust the DC input level until all transitional bits of the output code are of equal value.

(3) Read the DC input signal level on the digital voltmeter and record this reading on figure 98-3 (USACC Form 669-R).

(4) Repeat subparagraphs (1) through (3) for all other positive and negative DC test levels or at least for the code levels shown in table 98-1.

(5) Before testing the demultiplexer, determine the channel 2 offset voltage by measuring the decoder voltage output for a coder zero input signal condition. Observe the oscilloscope trace for codes 01111111 and 11111111 to verify transition from code number 127 and 128 respectively, for the zero signal input condition. Read the decoder output level and record the measured results.

(6) Adjust the DC input to the coder until the code for the selected test point is as shown in figure 98-3 (USACC Form 669-R) or table 98-1.

(7) Observe the oscilloscope trace to verify the correct code input to the demultiplexer.

(8) Measure the decoder DC output level with the digital voltmeter and record the measured value on figure 98-3 (USACC Form 669-R).

(9) Determine the actual output level by correcting the measured value by the DC offset value obtained in subparagraph (5), above. Enter the actual voltage level on the data sheet. Calculate the actual output voltage by:

Actual output = measured output - offset voltage.

(10) Repeat subparagraphs (6) through (9), above, for all codes shown in table 98-1 or figure 98-3 (USACC Form 669-R) as applicable.

(11) If measuring the levels and codes with an audio input signal, adjust the oscillator to 1020 Hz and connect the equipment as shown in figure 98-4.

(12) Adjust the oscillator input for the maximum permissible input to the channel. This should represent maximum DC voltage at the coder input. Reduce the input level in steps while observing the oscilloscope for a code change. At each code change, record the digital voltmeter input and output levels of the coder/decoder. Continue reducing the input until the code representing no modulation input is obtained.

(13) If directed, plot a graph of the input level versus output on figure 3-4 (DD Form 2094).

c. Code Level Stability.

(1) Connect the test equipment as shown in figure 98-5.

(2) Turn all voice frequency channels off. Set the unit for 24 channels.

(3) Terminate all voice frequency channels inputs into 600 ohms.

(4) Adjust the oscilloscope to observe the PCM (byte) output of channel 1. From figure 98-3 (USACC Form 669-R), determine the code level that corresponds with the observed bit pattern and record this level on the data sheet.

(5) Repeat subparagraph (3), above, for channels 2 through 24. Determine the maximum difference between the code levels of any two channels and record this data on figure 98-3 (USACC Form 669-R).

(6) Annotate the maximum and minimum code levels on the data sheet. Calculate the difference between code levels from:

Max - min = code diff

For example:

Max = 129 min = 127 diff = 2

(7) Connect the test oscillator to the input of channel 1 transmit as shown in figure 98-5. Set the oscillator frequency to 1020 Hz at 0 dBm0. Monitor the channel 1 signal at the input to the compressor coder card and verify that the voltage level increases to +3 dBm0. Record the maximum DC voltage. Repeat at other voice frequency input levels, if required.

98-5. DATA RECORDING AND ANALYSIS.

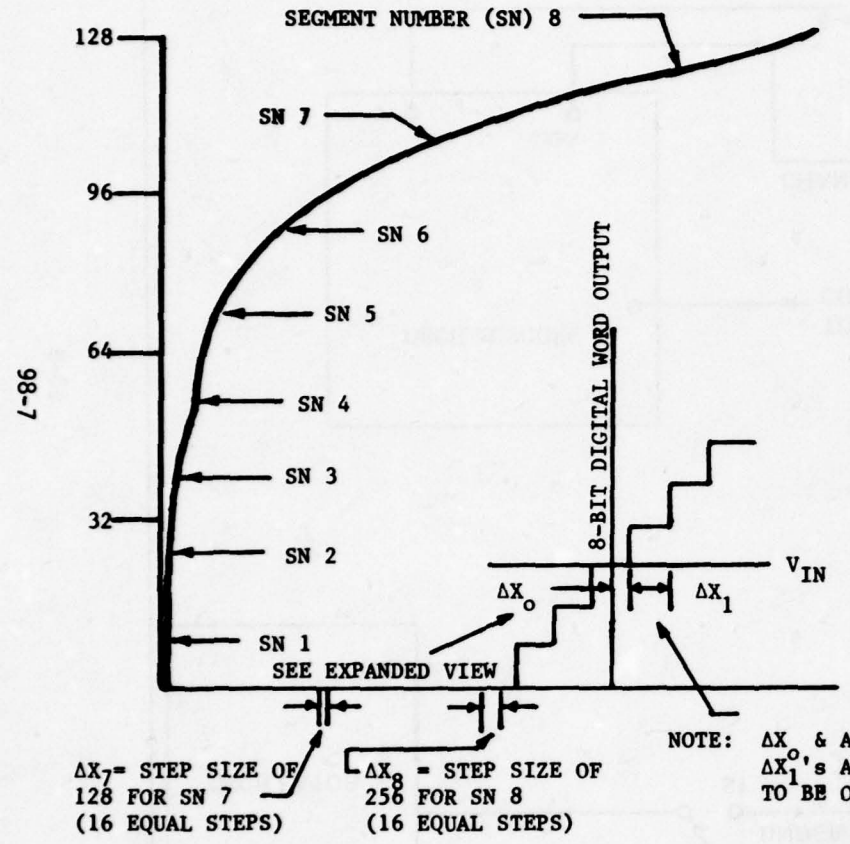
a. Review all test results for completeness and compliance with test requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

Table 98-1. Folded Binary Code Structure Segment Points

BINARY COUNT	CODE	RELATIVE INPUT LEVEL	COMPANDER SEGMENT
255	10000000	1	--
239	10010000	1/2	8
223	10100000	1/4	7
207	10110000	1/8	6
191	11000000	1/16	5
175	11010000	1/32	4
159	11100000	1/64	3
143	11110000	1/128	2
128	11111111	0	1
127	01111111	0	1
112	01110000	-1/128	2
96	01100000	-1/64	3
80	01010000	-1/32	4
64	01000000	-1/16	5
48	00110000	-1/8	6
32	00100000	-1/4	7
16	00010000	-1/2	8
1	00000001	-1	--



EXPANDED VIEW		
SEGMENT END POINTS	STEP SIZE	SEGMENT NUMBER
$X_o = 0$	$\Delta X_o = 1$	1
$X_1 = 1$	$\Delta X_1 = 2$	
$X_{16} = 31$	$\Delta X_2 = 4$	2
$X_{32} = 95$	$\Delta X_3 = 8$	3
$X_{48} = 223$	$\Delta X_4 = 16$	4
$X_{64} = 479$	$\Delta X_5 = 32$	5
$X_{80} = 991$	$\Delta X_6 = 64$	6
$X_{96} = 2015$	$\Delta X_7 = 128$	7
$X_{112} = 4063$	$\Delta X_8 = 256$	8
$X_{128} = 8159$		

98-7

CCP 702-11

Figure 98-1. Efficiently digitally linearizable coder threshold levels and step sizes (normalize to 8159).

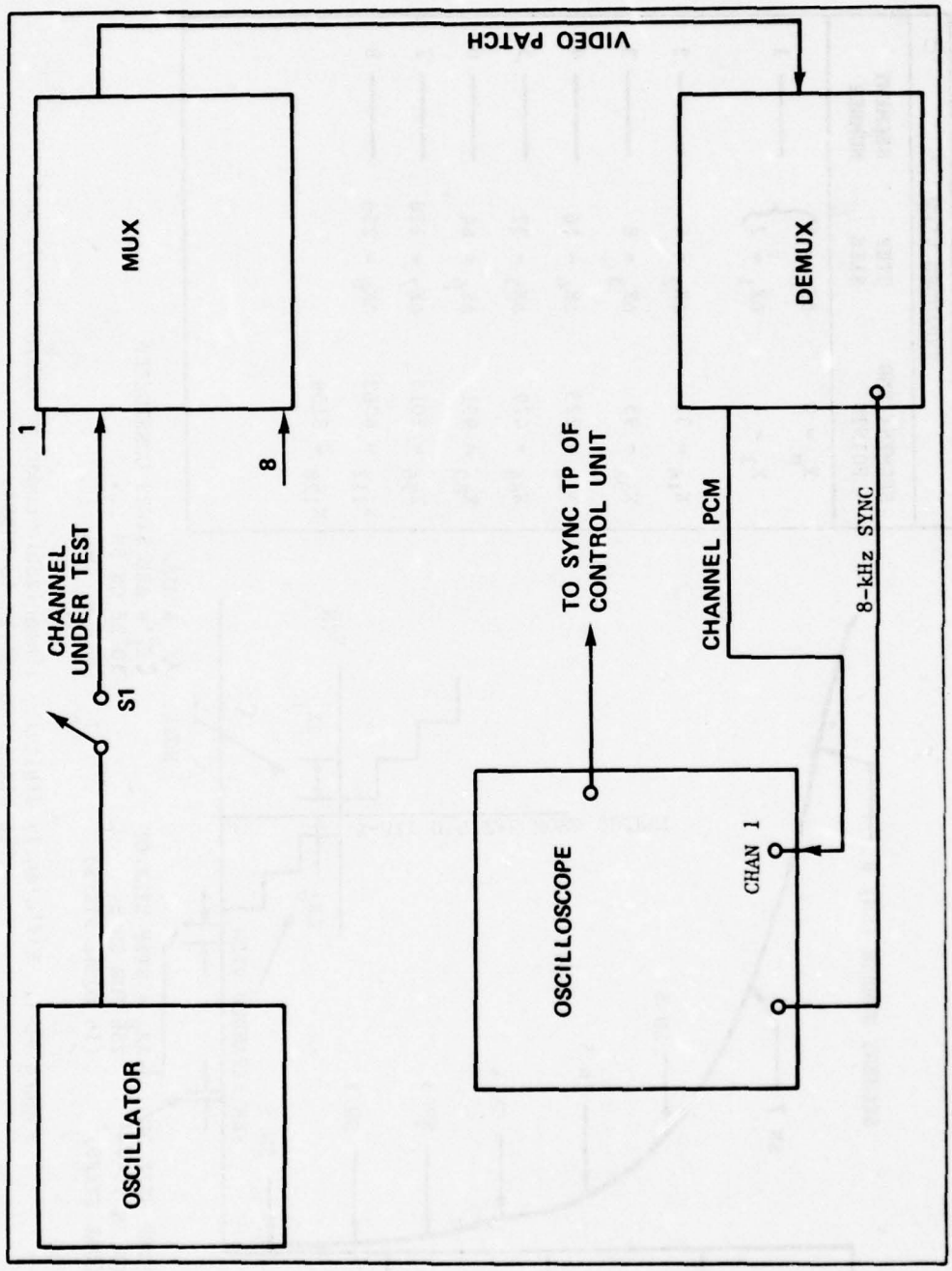


Figure 98-2. PCM format test setup.

CODER/DECODER PERFORMANCE (CCR 702-1-3) DATA SHEET		DATE (DAY, MO, YEAR)
		TEST ENGR SIGNATURE
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION

CODE LEVEL STABILITY

CHAN NO.	OBSERVE CODE LVL	CODE LVL SPEC LIMITS		MAX DIFF BTWN ANY TWO LVL		SPEC LIMIT	VOLTAGE LVL BTWN LIMITS	
		MIN	MAX	LEVELS			C	NC
1		122	133					
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24		122	133					

COMMENTS

USACC FORM 669-R
1 MAY 79

Page 1

Figure 98-3. Coder/decoder performance data sheet.

CODE TYPE AND LEVEL									
☐ POSITIVE INPUT					☐ NEGATIVE INPUT				
INPUT LEVEL (mV)	CODE NO.	PCM CODE	ACTUAL INPUT (mV)	SPEC RANGE (mV)	INPUT LEVEL (mV)	CODE NO.	PCM CODE	ACTUAL INPUT (mV)	SPEC RANGE (mV)
	1	00000001				64	01000000		
	2	00000010				65	01000001		
	7	00000111				73	01001001		
	8	00001000				74	01001010		
	15	00001111				79	01001111		
	16	00010000				80	01010000		
	16	00010000				80	01010000		
	17	00010001				81	01010001		
	22	00010110				84	01010100		
	23	00010111				85	01010101		
	31	00011111				95	01011111		
	32	00100000				96	01100000		
	36	00100100				96	01100000		
	37	00100101				97	01100001		
	47	00101111				101	01100101		
	48	00110000				102	01100110		
	48	00110000				111	01101111		
	49	00110001				112	01110000		
	57	00111001				112	01110000		
	58	00111010				113	01110001		
	63	00111111				118	01110110		
	64	01000000				119	01110111		

PCM CODE	CODE NO.	CODER INPUT (mV)	DECODER OUTPUT (mv)	MEAS DECODER OUTPUT (mV)	ACTUAL DECODER OUTPUT (mV)	SPECIFICATION LIMITS (mV)	
						MIN	MAX
01111111	127						
01111000	120						
01110000	112						
01101111	111						
01101000	104						
01100000	96						
01011111	95						

USACC FORM 669-R
1 MAY 79

Figure 98-3. Coder/decoder performance data sheet. (continued)

CODE TYPE AND LEVEL (CONT)							
☐ POSITIVE INPUT					☐ NEGATIVE INPUT		
PCM CODE	CODE NO.	CODER INPUT (mV)	DECODER OUTPUT (mV)	MEAS DECODER OUTPUT (mV)	ACTUAL DECODER OUTPUT (mV)	SPECIFICATION LIMITS (mV)	
						MIN	MAX
01011000	88						
01010000	80						
01001111	79						
01001000	72						
01000000	64						
00111111	63						
00111000	56						
00110000	48						
00101111	47						
00101000	40						
00100000	32						
00011111	31						
00011000	24						
00010000	16						
00001111	15						
00001000	8						
00000001	1						
10000000	255						
10001000	247						
10001111	240						
10010000	239						
10011000	231						
10011111	224						
10100000	223						
10101000	215						
10101111	208						
10110000	207						
10111000	199						
10111111	192						
11000000	191						
11001000	183						
11001111	176						

USACC FORM 669-R
1 MAY 79

Figure 98-3. Coder/decoder performance data sheet. (continued)

CCP 702-11

CODE TYPE AND LEVEL (CONT)							
☐ POSITIVE INPUT					☐ NEGATIVE INPUT		
PCM CODE	CODE NO.	CODER INPUT (mV)	DECODER OUTPUT (mV)	MEAS DECODER OUTPUT (mV)	ACTUAL DECODER OUTPUT (mV)	SPECIFICATION LIMITS (mV)	
						MIN	MAX
11010000	175						
11011000	167						
11011111	160						
11100000	159						
11101000	151						
11101111	144						
11110000	143						
11111000	135						
11111111	128						

COMMENTS

USACC FORM 669-R
1 MAY 79

Figure 98-3. Coder/decoder performance data sheet. (continued)

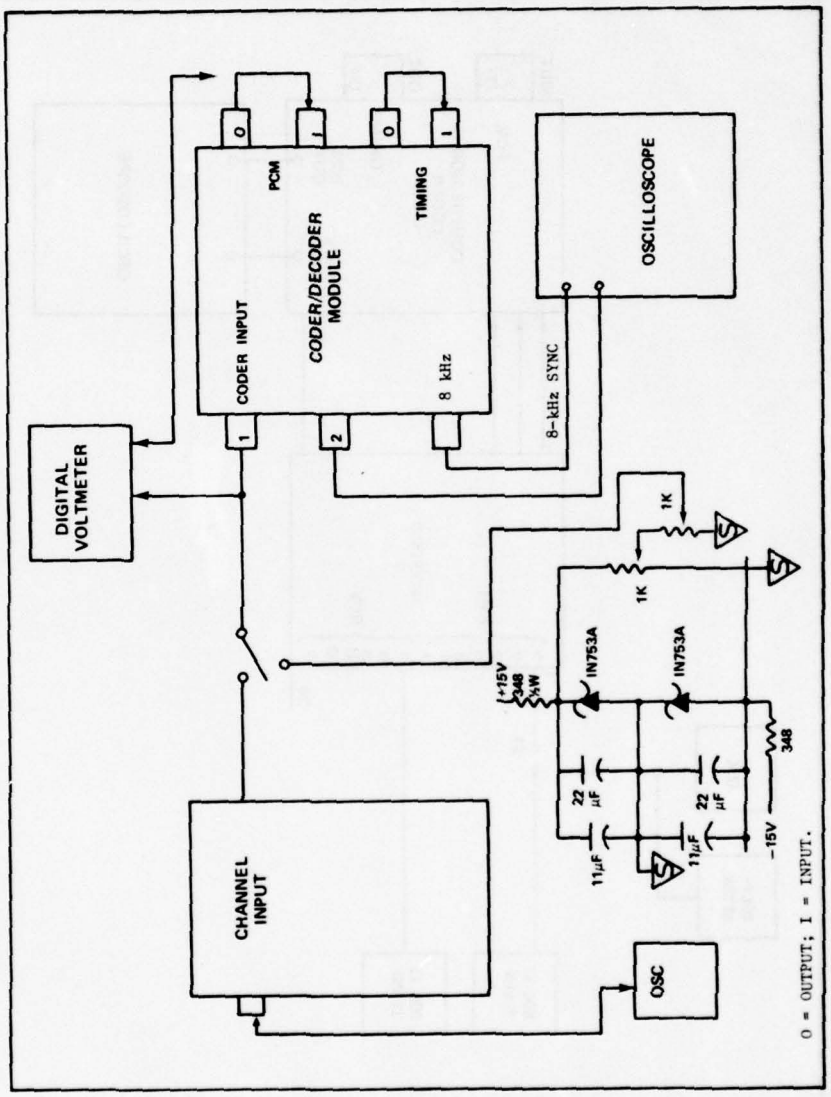


Figure 98-4. Code type and level test setup.

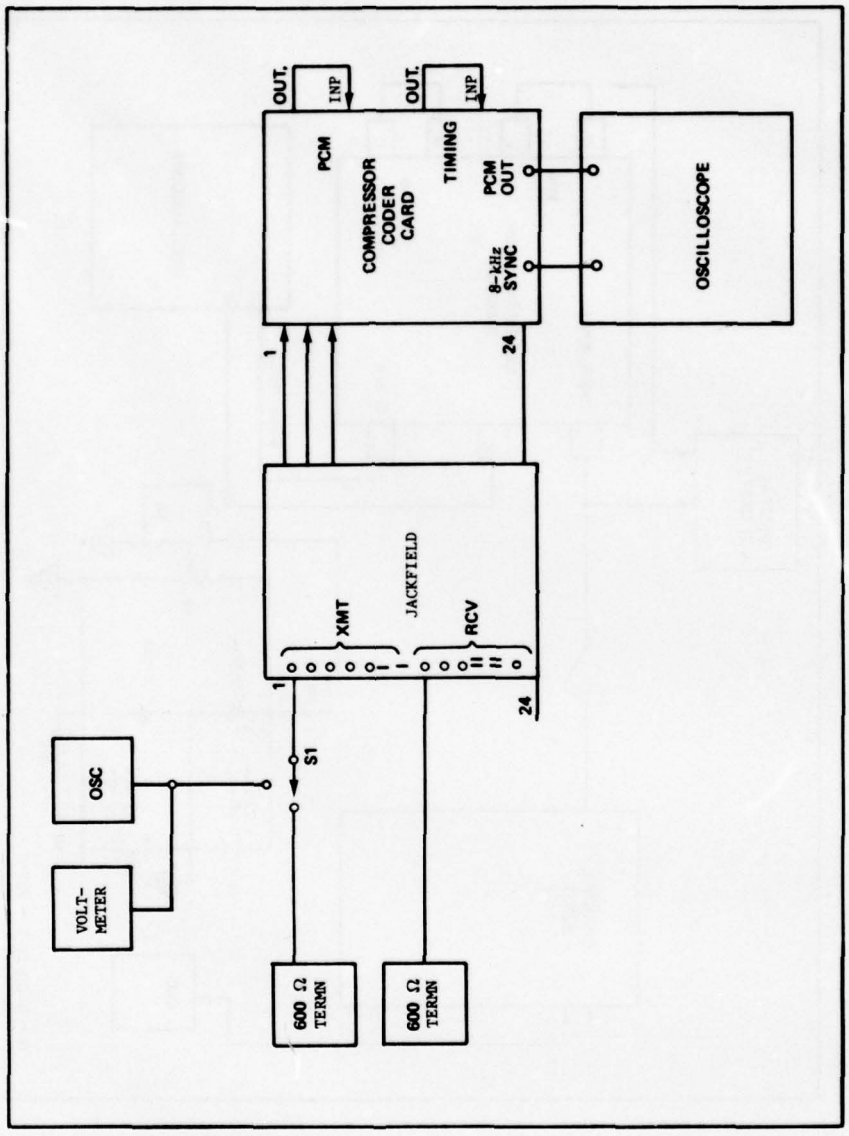


Figure 98-5. Code level stability test setup.

CHAPTER 99

DIGITAL INTERFACE RISE AND FALL TIMES (DT-296)

99-1. GENERAL.

a. The purpose of this test is to measure:

(1) Pulse amplitude of logics 1 and 0.

(2) Pulse width.

(3) Pulse rise and fall times.

b. This test may not be required during onsite test activities since the measured parameters are primarily determined during equipment design.

c. This test may be performed on contractor EF&I systems and equipment to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

99-2. SPECIFICATIONS.

a. The TD-1192 (AN/FCC-98) NRZ data output and the square wave timing outputs rise and fall times (T_R and T_F, fig. 99-1) when measured between the 10- and 90-percent points shall be less than 100 nsec. The bipolar output maximum rise and fall times shall be 80 nsec in accordance with the D3 channel bank requirements as shown in DT-277. (CCC-74047)

b. The TD-1193 NRZ data outputs and the square wave timing output rise and fall times (T_R and T_F, fig. 99-1) when measured between the 10- and 90-percent points shall be greater than 4 nsec but less than 12 nsec for high speed data rates and less than 100 nsec for low speed data rates. The bipolar outputs, T_R and T_F, shall be less than 80 nsec. (CCC-74048)

c. The AN/FRC-162 and VICOM 4000-2 system maximum rise and fall times shall be 80 nsec.

d. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

99-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. BER test set.

c. Connector, adapters, and cables, as required.

d. Precision terminations, as required.

99-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 99-2 and allow approximately 30 minutes for warmup and stabilization.

b. Connect the multiplex/demultiplex for 24-channel bipolar or NRZ operation.

c. At the transmit end:

(1) Set the BER test set to provide the required data rates and clock to each of the digital data channels.

(2) Set the oscilloscope differential amplifier for 2 volts per division (DC input). Connect the oscilloscope differential amplifier to the MBS transmit data test point.

(3) Set the oscilloscope dual channel amplifier for 2 volts per division. Add mode with channel 2 polarity inverted and trigger to channel 1. Connect the oscilloscope dual amplifier to the MBS transmit clock test point.

(4) Set the oscilloscope time base for 0.1 µsec per division. Connect the oscilloscope trigger to the control line on the transmit interface unit.

(5) *If bipolar operation*, set the BER test set to provide all 1's to all data channels. Using the differential amplifier, locate persistent pulses and measure the rise and fall times of the data pulse. Also measure and record the pulse width and amplitude of the logic 1.

(6) For NRZ, set the BER test set to provide an alternating 1010 pattern input to the unit under test.

(7) Using the differential amplifier, locate the pulses of the channel/frame under test. Measure the rise and fall times of the data pulse and the transmit clock pulse.

(8) Repeat the above for the different data rates and channel configurations.

d. At the receive end:

(1) Set the BER test set to provide the proper data rates and clock to the transmit channel under test. Connect the transmit output PCM/TDM to the receive end as shown in figure 99-2.

NOTE: The built-in loopback switch on the unit may be used instead of patching if required. The BER test set should provide an alternating 1010 pattern to the input data channel/port.

(2) Connect the oscilloscope differential amplifier to the data channel receive data test point.

(3) Connect the oscilloscope dual amplifier to the data channel receive clock which is used for synchronization of the oscilloscope channel. Using the oscilloscope differential amplifier and dual amplifier controls, locate and measure the rise and fall times of the data and clock pulse.

(4) Set the oscilloscope time base for proper display of the data pulse and connect the differential amplifier to the transmit clock out (synchronous channel only).

(5) Repeat subparagraph (3), above, and record the results on figure 99-3 (USACC Form 670-R). Repeat subparagraphs (1) through (4) for the remaining digital channels.

(6) Connect a 78-ohm precision termination across the differential amplifier input. Connect the amplifier input to the transmit timing output connector. Measure and record the rise and fall times of the transmit clock pulse.

(7) Connect the oscilloscope differential amplifier through a 78-ohm precision termination to the receive clock output connector. Measure and record the rise and fall times of the clock pulse using the oscilloscope dual amplifier controls.

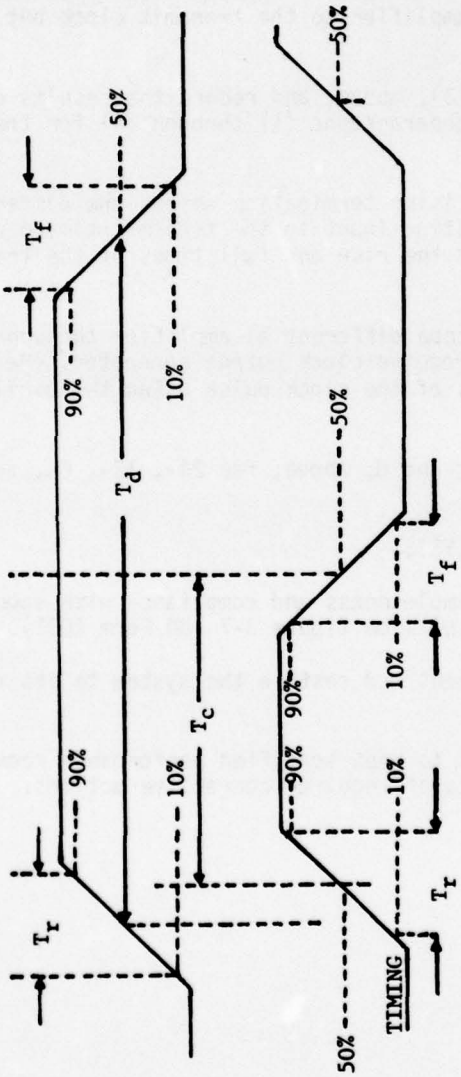
e. Repeat subparagraphs c and d, above, for 24-, 12-, 6-, and 3-channel operation, if applicable.

99-5. DATA RECORDING AND ANALYSIS.

a. Review all data for completeness and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.



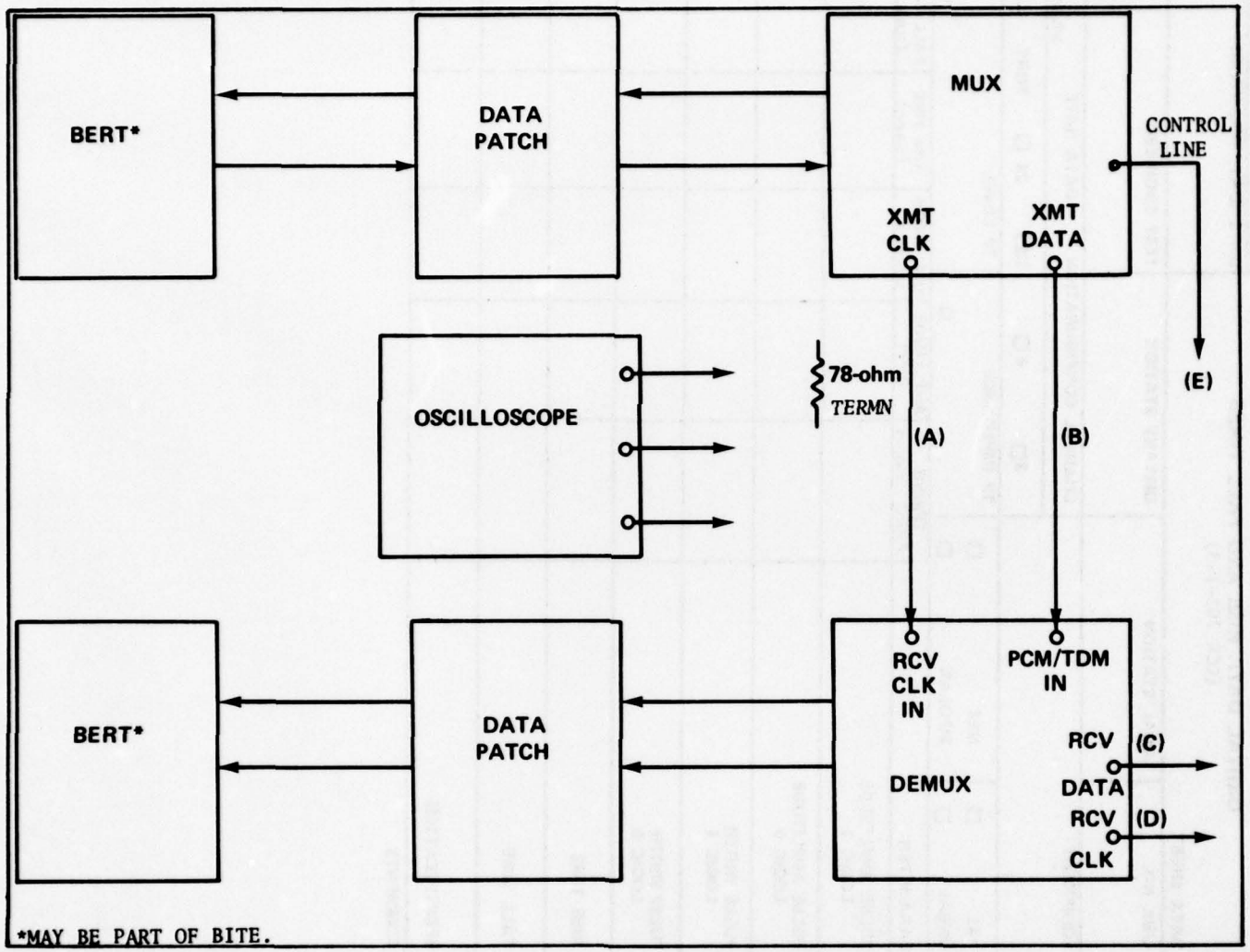
T_d = NOMINAL DATA UNIT INTERVAL.

T_c = NOMINAL TIMING INTERVAL.

T_f = FALL TIME.

T_r = RISE TIME.

Figure 99-1. Data/timing phase relationship.



CCP 702-11

Figure 99-2. Digital data rise and fall times test setup.

DIGITAL DATA RISE AND FALL TIMES (CCR 702-1-3) DATA SHEET			PAGE OF PAGES; DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		CHANNEL CONFIGURATION 3☐ 6☐ 12☐ 24☐ PORT —	DATA RATE mb/s
BAL ☐ UNBAL ☐	NRZ ☐ BIPOLAR ☐	TP IMPEDANCE Ω	TP LEVEL VPP

PARAMETER	TIMING FREQ (MHz)	AMPLITUDE (VPP)	PULSE WIDTH (usec)	RISE TIME (usec)	FALL TIME (usec)
PULSE AMPLITUDE LOGIC 1					
PULSE AMPLITUDE LOGIC 0					
PULSE WIDTH LOGIC 1					
PULSE WIDTH LOGIC 0					
RISE TIME					
FALL TIME					
SPECIFICATION					

COMMENTS

USACC FORM 670-R
1 MAY 79

Figure 99-3. Digital data rise and fall times data sheet.

CHAPTER 100

DATA AND TIMING SIGNAL RINGING (DT-297)

100-1. GENERAL.

a. The purpose of this test is to measure and determine the overshoot of the data and timing signals of the digital multiplex equipment.

b. This test would normally not be a routine field test unless the BER test or some other parameter did not meet specified requirements.

c. This test may be performed on contractor EF&I systems to verify that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

100-2. SPECIFICATIONS.

a. The multiplex equipment shall operate in accordance with paragraph 4.3.1.3 of MIL-STD-188-100.

b. The TD-1192 (AN/FCC-98) square wave timing and NRZ data wave shape delivered to its characteristic impedance through 10 feet of cable shall not overshoot or undershoot its final value by more than 15 percent of that value. The overshoot for the bipolar signal shall be in accordance with AT&T D3 channel bank specifications as shown in figure 100-1. Pulse characteristics of the D3 channel bank are also shown in table 100-1. (CCC-74047).

Table 100-1. AT&T D3 Channel Bank Pulse Characteristics (Refer to Figure 100-1)

PULSE CHARACTERISTICS	REQUIREMENT
Base-to-peak height	6±0.6 volts
Unbalance in height of positive and negative pulse	±0.3 volt
Half-amplitude width	324±30 nsec
Unbalance in width of positive and negative pulse.	±15 nsec
Maximum rise or fall times	80 nsec
Maximum density	Normally 1 in 8, no more than 15 consecutive zeros.

c. The TD-1193 square wave timing and NRZ data wave shapes delivered to their characteristic impedance through 10 feet of cable shall not overshoot or

undershoot their final value by more than 15 percent of that value. The overshoot for the bipolar signal at the trailing edge shall be 20 to 40 percent of the pulse height decaying to 10 percent or less of the peak-to-peak value within 400 nsec of the zero crossing. (CCC-74048)

d. The AN/FRC-162 and VICOM 4000-2 system shall operate essentially the same as stipulated in subparagraph b, above.

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

100-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. RG-108A/U coaxial cable.

c. Precision terminating resistors.

d. Connectors, adapters, and cables, as required.

100-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 100-2a and allow approximately 30 minutes for warmup and stabilization.

b. Set the oscilloscope differential amplifier for ±DC input at 1 volt per division and connect it to the MBS transmit data test point.

c. Set the oscilloscope time base to 50 nsec per division for the AN/FRC-162 and VICOM 4000-2 and TD-1192 equipment. For the TD-1193 the time base should be set for 1 µsec per division. Connect the oscilloscope trigger input to the control line (TP-3) of the multiplex under test.

NOTE: If a differential amplifier is not used, an alternate test setup is shown in figure 100-2b.

d. Set the BER test set to provide the required data rates, clock, and impedance to correspond to the channel under test. Set the BER test set to provide an alternating 1010 input pattern to the channel under test.

e. Adjust the oscilloscope delay multiplier to view the leading edge of a stable bit in an 8-bit logic 1 and 0 sequence. Measure and record the overshoot (+) or undershoot (-) of the logic 1 and 0 pulses as compared to their final value as shown in figure 100-2c.

f. Observe and record the time for the signal to decay to 10 percent of its overshoot value.

g. Repeat the above for other transmit timing output and data rates.

h. Connect the oscilloscope differential amplifier to the receive data test point and adjust the delay multiplier to view the leading edge of a stable bit in an 8-bit logic 1 and 0 sequence. Measure and record the overshoot value from the final level as shown in figure 100-2c.

i. Adjust the oscilloscope delay multiplier to view the trailing edge of a stable bit in an 8-bit logic 1 and 0 sequence. Record the overshoot (-) on figure 100-3 (USACC Form 671-R).

j. Connect the oscilloscope differential amplifier input to the receive clock test point and repeat subparagraph i, above.

k. Connect the oscilloscope differential amplifier to the transmit synchronization clock and repeat subparagraph i, above.

l. Connect the oscilloscope to the master clock out test point and repeat subparagraph i, above.

m. Connect the oscilloscope to the receive recovered clock test point and repeat subparagraph i, above.

n. Repeat subparagraphs b through m, above, for other channels and data input/output and clock rates.

o. Calculate the tolerance from:

Acceptable limits = final level x tolerance percentages
= ± *final level*

For example:

Measured final level (logic 1) = 3.00 volts tolerance percentage
= 3.00 x 0.15 = 0.045

acceptable limits = ±0.04 volt
or
2.96 to 3.04 volts.

100-5. DATA RECORDING AND ANALYSIS.

a. Record all data on the data sheet. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and return the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

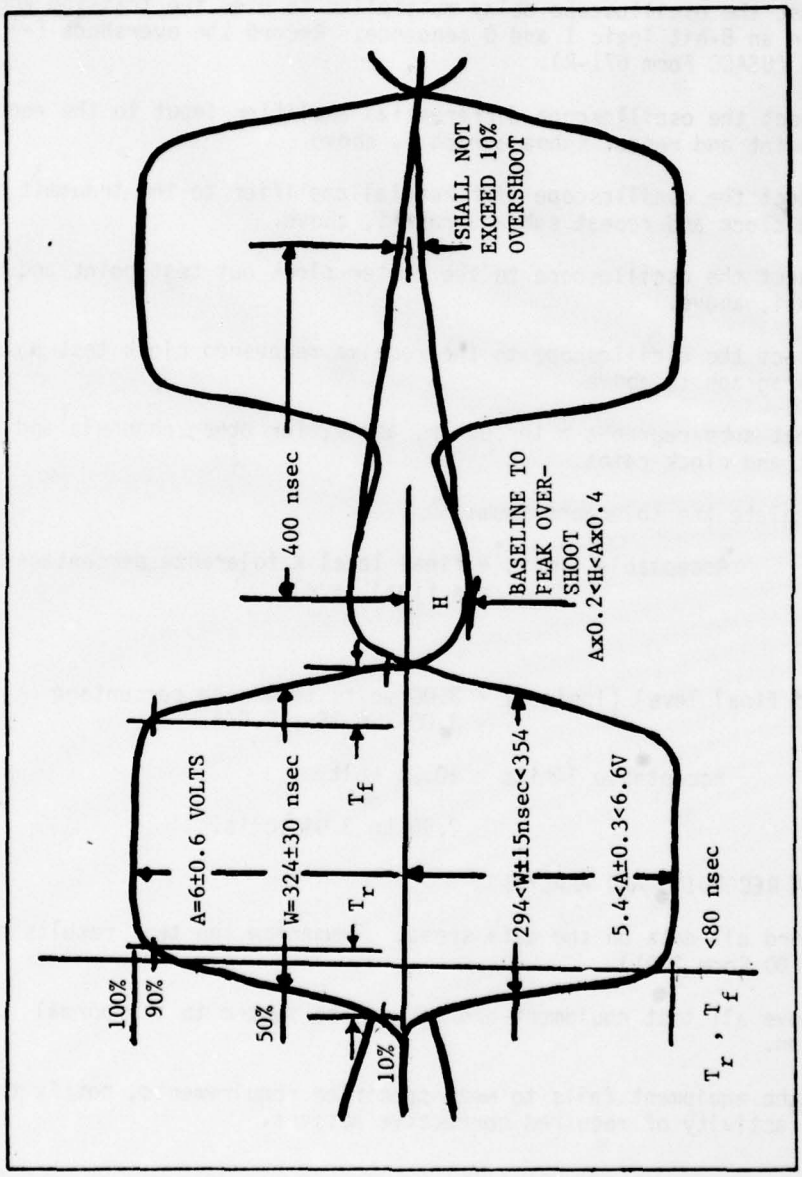


Figure 100-1. Typical output pulse (AT&T D3 channel bank).

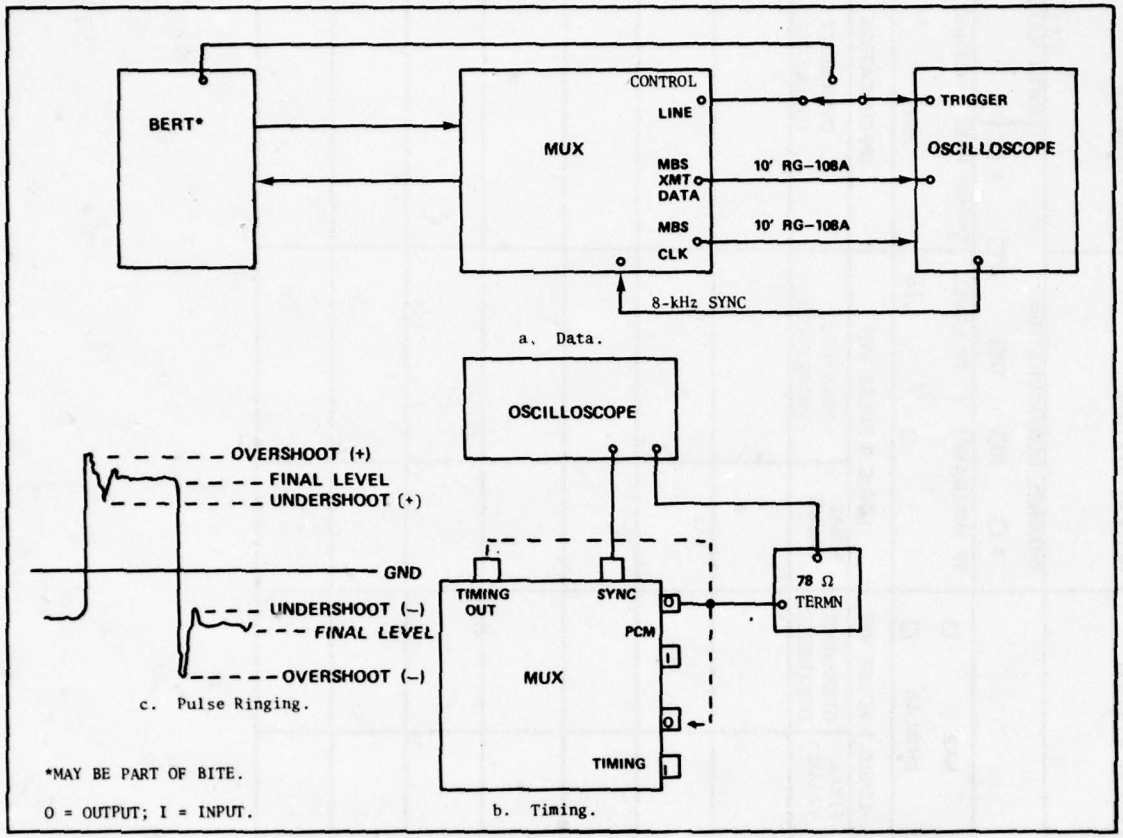


Figure 100-2. Data, timing, and pulse ringing test setups.

DATA AND TIMING SIGNAL RINGING
(CCR 702-1-3)

PAGE OF PAGES

DATE (DAY, MO., YEAR)

DATA SHEET

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

EQUIPMENT	CHANNEL CONFIGURATION	DATA RATE
	3 ☐ 6 ☐ 12 ☐ 24 ☐ 8 ☐	mb/s

BAL ☐ UNBAL ☐	NRZ ☐ BIPOLAR ☐	TP IMPEDANCE Ω	TP LEVEL VPP	TIMING FREQ MHz	METHOD USED

PARAMETER	LOGIC 1 PULSE VPP		LOGIC 0 PULSE VPP		SPECIFICATION
	FINAL VALUE	OVERSHOOT UNDERSHOOT	FINAL VALUE	OVERSHOOT UNDERSHOOT	OVERSHOOT UNDERSHOOT
PCM/TDM XMT DATA					
TIMING					
MASTER TIMING					
PCM/TDM RCV DATA					
RCV CLOCK					
XMT SYNC CLOCK					
RECOVERED RCV CLK					

COMMENTS

USACC FORM 671-R
1 MAY 79

Figure 100-3. Data and timing signal ringing data sheet.

CHAPTER 101

FRAME SYNCHRONIZATION ACQUISITION AND REACQUISITION TIME (DT-298)

101-1. GENERAL.

a. The purpose of this test is to measure the digital multiplex frame synchronization acquisition and reacquisition time.

b. This test would not normally be a routine onsite test since specialized test equipment may be required, and the fact that it would be verifying a design function.

c. This test may be performed on contractor EF&I systems to verify that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

101-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) The multiplex terminal in any mode of operation shall acquire frame snychronization within 50 msec, 90 percent of the time, upon application of data and timing to the input of the demultiplexer of the multiplex terminal with a randomly distributed BER of $1x10^{3}$ in the demultiplexer bit stream. While BCI is maintained, the mean time to loss of synchronization shall not be less than 6 hours with a randomly distributed BER as high as $1x10^{3}$. An external frame search inhibit capability shall be provided. Frame search shall be inhibited whenever the external inhibit command is present. The command shall be a transistor-transistor logic level applied to a connector on the multiplex terminal.

(2) With the multiplex terminal maintaining frame synchronization, the 50-kb/s channel card shall acquire frame synchronization within 50 msec, 90 percent of the time, upon application of the data signal to the input of the 50-kb/s data card with a randomly distributed BER of $1x10^{3}$. While BCI is maintained, the mean time to loss of synchronization shall not be less than 6 hours with a randomly distributed BER as high as $1x10^{3}$.

b. The following criteria applies to the TD-1193. (CCC-74048)

(1) The TDM at all bit rates (table 101-1) shall acquire frame synchronization within 131,000 bits, 90 percent of the time, upon application of the data and timing to the input of the TDM with a randomly distributed BER of $1x10^{2}$ in the demultiplex bit stream. While BCI is maintained, the mean time to loss of synchronization shall not be less than 24 hours with a randomly distributed BER as high as $1x10^{2}$. An external frame search inhibit capability shall be provided. Frame search shall be inhibited whenever the external inhibit command is present. The command shall be applied to a connector on the TDM.

Table 101-1. Mission Bit Stream Characteristics

NUMBER OF 1.544-mb/s PORTS	NOMINAL TIMING RATE (MHz)	NOMINAL DATA RATE (mb/s)	NOMINAL DATA UNIT INTERVAL (µsec)	NOMINAL TIMING PULSE WIDTH (µsec)	TIMING SIGNAL FORMAT	DATA SIGNAL FORMAT
2	3.232	3.232	0.3094	0.1547		
4	6.464	6.464	0.1547	0.0774	Polar	
6	9.696	9.696	0.1031	0.0516	square	NRZ
8	12.928	12.928	0.0774	0.0387	wave	

(2) In the event of loss of BCI up to and including ±2 bits, the total time for the TDM at all bit rates to reach a decision that frame has been lost and to regain frame shall not exceed 131,000 consecutive bit time intervals, 90 percent of the time, with a BER of $1x10^{3}$ for randomly distributed errors over the entire TDM input MBS. This time period extends from the introduction or loss of the bits until the TDM has reacquired frame and the loss-of-frame indicator has been extinguished. For more than 2 bits, once the loss of BCI is detected, the acquisition time contained in subparagraph (1), above, applies.

NOTE: The AN/FRC-162 and VICOM 4000-2 system is not a part of the original onsite test and acceptance procedures. Refer to the equipment technical manual.

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

101-3. TEST EQUIPMENT REQUIRED.

a. Frequency counter HP 5300/5308.

b. Printer.

c. BER test set.

d. Oscilloscope.

101-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 101-1 and allow approximately 30 minutes for warmup and stabilization.

b. Set the counter to measure time interval A to B (A-, B+). Connect the counter A input to the demultiplex data inhibit circuit and the B input to the loss-of-frame circuit.

c. Set the BER test set data rate, level, format, and impedance to correspond to the level at which the signal is to be inserted.

d. With switch S3, momentarily interrupt the clock and data signal and measure the time required for the demultiplexer to acquire synchronization.

e. Repeat subparagraph d, above, 99 times and record the measured times on figure 101-2 (USACC Form 672-R).

f. Repeat subparagraph d for the 12-, 6-, and 3-channel configurations.

g. Connect the BER test set to the 50-kb/s channel card. Set the BER test set output to correspond to the format, level, and impedance of the channel card. Set the BER test set to provide a randomly distributed error rate of $1x10^{3}$. Verify that the terminal has synchronized and all BCI indicators are extinguished.

h. With switch S3, momentarily interrupt the data and clock. Record the time for the terminal to acquire synchronization. Repeat this procedure 99 times. Verify that the percentage of readings taken are within specifications.

i. Set the BER test set to provide a BER of $1x10^{3}$. After 6 hours, determine from the recording that the terminal did not lose synchronization. For the TD-1193, record data for 24 hours at a BER of $1x10^{2}$.

j. Set the BER test set to delete 2 data bits and set the demultiplexer to frame search inhibit. Verify and record the time for activation of the loss-of-frame alarm.

k. Repeat subparagraphs b through j, above, for other channel configurations.

l. For frame loss and reacquisition time, set the counter to start counting when the clock delete switch (S2) is opened and to stop counting when the loss-of-frame synchonization goes to a logic 1 level.

m. Momentarily open the switch of the clock circuit to delete one clock pulse. Measure and record the total time required for the demultiplexer to reach out-of-synchronization and reacquire synchronization. Repeat this procedure 99 times to determine the average time for the demultiplexer to acquire synchronization.

n. Repeat subparagraphs b through m, above, for other channel configurations and data rates.

101-5. DATA RECORDING AND ANALYSIS.

a. Record all data on the data sheet and verify that the equipment meets specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

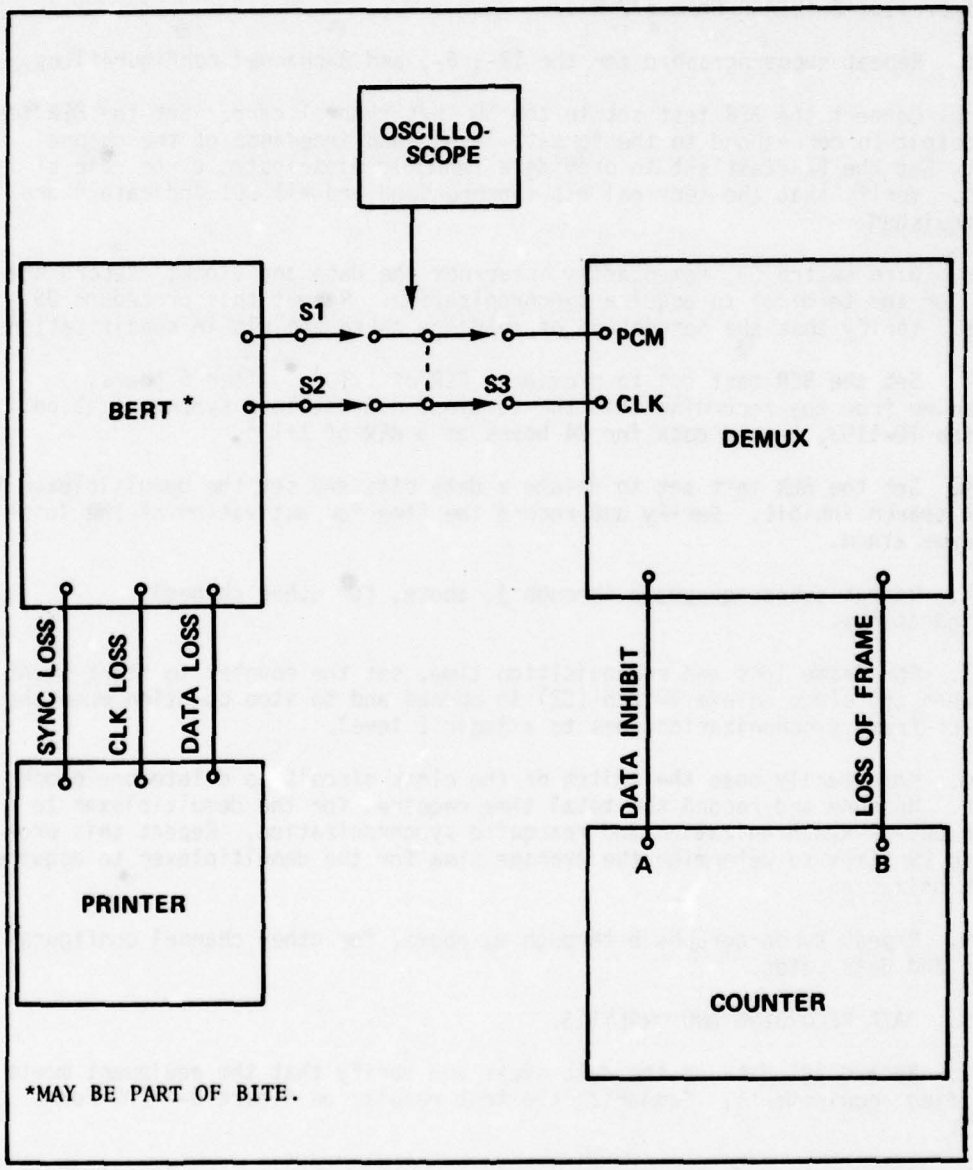


Figure 101-1. Frame synchronization and reacquisition time test setup.

LOSS OF FRAME AND REACQUISITION TIME (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		CHANNEL CONFIGURATION	DATA RATE mb/s / FORMAT NRZ ☐ BIPOLAR ☐
BIT ERROR RATE 0☐ $1x10^{-2}$ ☐ $1x10^{-3}$ ☐		SPECIFICATION	

RUNS (msec OR BITS)				SYNC MAINTAINED			
1 → 25	26 → 50	51 → 75	76 → 100	C ☐ NC ☐			
				SYNC SAMPLING			
				RUN NO.	PERIOD	C	NC

CHAPTER 102

DATA AND TIMING SIGNAL PHASING AND SAMPLING INTERVAL (DT-299)

102-1. GENERAL.

a. The purpose of this test is to measure the zero crossing of the positive-to-negative transition of the output timing signal as compared to the nominal data unit interval of the NRZ signal. A typical data and timing relationship waveform is shown in figure 102-1.

b. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. However, it is more of a design verification test than a routine onsite test.

102-2. SPECIFICATIONS.

a. The multiplex equipment shall operate in accordance with paragraph 4.3.1.6.3 of MIL-STD-188-100.

b. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) *Phasing*. The zero crossing of the positive-to-negative transition of the output timing signal shall occur within ±4 percent of the center of the nominal data unit interval of the output NRZ signal as shown in figure 102-1.

(2) *Sampling*. At the digital input, NRZ data and timing signals shall be detected and processed with the zero crossing of the positive-to-negative transition of the timing signal occuring within ±25 percent of the center of the nominal data unit interval of the NRZ signal as shown in figure 15-4.

c. The TD-1193 shall conform to the same requirements as the TD-1192. (CCC-74048)

d. The AN/FRC-162 and VICOM 4000-2 system shall conform to basically the same requirements as the TD-1192 (AN/FCC-98) and the TD-1193.

e. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

102-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Frequency counter.

c. Oscilloscope.

d. Adapters, connectors, and cables, as required.

102-4. TEST PROCEDURES.

a. Phasing.

(1) Connect the test equipment as shown in figure 102-2 if using a frequency counter to measure the difference between the data and timing signals. Allow approximately 30 minutes for warmup and stabilization.

(2) Set the multiplex for 24-channel NRZ operation in accordance with the equipment technical manual and connect channel A of the frequency counter timing module to the MBS transmit data. Connect the channel B input to the MBS transmit clock.

(3) Set the frequency counter timing module to time average (A - B), automatic, channel A slope to positive (+) and channel B slope to negative (-). Set the common-separate-check mode switch of channel B to separate. Adjust the input level controls until a stable display is obtained.

(4) Set the BER test set to provide the required data and clock rates to each digital channel to be tested.

(5) After 5 seconds, record the counter reading on figure 102-3 (USACC Form 673-R). Reset the counter to zero and take another 5-second sample. Repeat this procedure for 10 consecutive readings and record each reading on the data sheet. Average the 10 readings and enter this value on the data sheet.

(6) For the receive end, set the BER test set to provide an alternating 1010 pattern and connect the receive data and receive clock as shown in figure 102-2. Repeat subparagraph (5), above. Record the results on the data sheet.

NOTE: If available, a vector phase meter may be used.

(7) Repeat subparagraphs (2) through (6), above, for all remaining data channels, except for the 0- to 20-kb/s channel module.

(8) If using an oscilloscope, connect the test equipment as shown in figure 102-2 and proceed as follows:

(a) Set the multiplex for operation at the maximum channel capacity and NRZ format.

(b) Connect the BER test set to the input of the data channel under test. Set the data and clock to the applicable data rate. Set the BER test set to provide an alternating 1010 pattern to the input of the device to be tested.

(c) Connect channel A of the oscilloscope to the transmit data output and adjust the controls to provide a stable display at the reference line. Connect channel B to the transmit timing output and adjust for a stable display.

(d) Measure and record the time difference between the trailing edge (logic 1 to 0 transition) of the timing signal and the center of the nominal unit interval of the transmit data stream as shown in figure 102-1. Measure and record the time difference between the leading edge (logic 0 to 1 transition) of the timing signal and the transition of the transmit data signal as shown in figure 102-1.

(e) Repeat subparagraphs (a) through (d), above, for other transmit data and clock rates.

(f) Repeat subparagraphs (a) through (e), above, with the oscilloscope connected to the receive MBS data and clock as shown in figure 102-2.

b. Sampling.

(1) Connect the test equipment as shown in figure 102-4.

(2) Set the BER test set for the required data and clock rates with a 1010 pattern and NRZ format. Set the BER test set for a clock offset of 25 percent of the nominal data unit interval as shown in figure 15-4. Measure this offset with the oscilloscope and compare the measured value to that displayed on the BER test set.

(3) Transmit data for 1 minute and observe that the error rate does not increase over that obtained without the clock offset. Also note that the terminal equipment does not lose frame synchronization. Record the results on the data sheet.

(4) Set the BER test set to provide randomly distributed errors of $1x10^3$ for the TD-1192 and $1x10^2$ for the TD-1193 and repeat subparagraph (3), above.

(5) Return the BER test set clock offset to normal and set the transmit data pattern to 25-percent offset from the nominal unit interval. Repeat subparagraph (4), above.

(6) Repeat subparagraphs (2) through (5), above, for the remaining data channels and data rates.

102-5. DATA RECORDING AND ANALYSIS.

a. Review all test data for completeness and accuracy of data. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

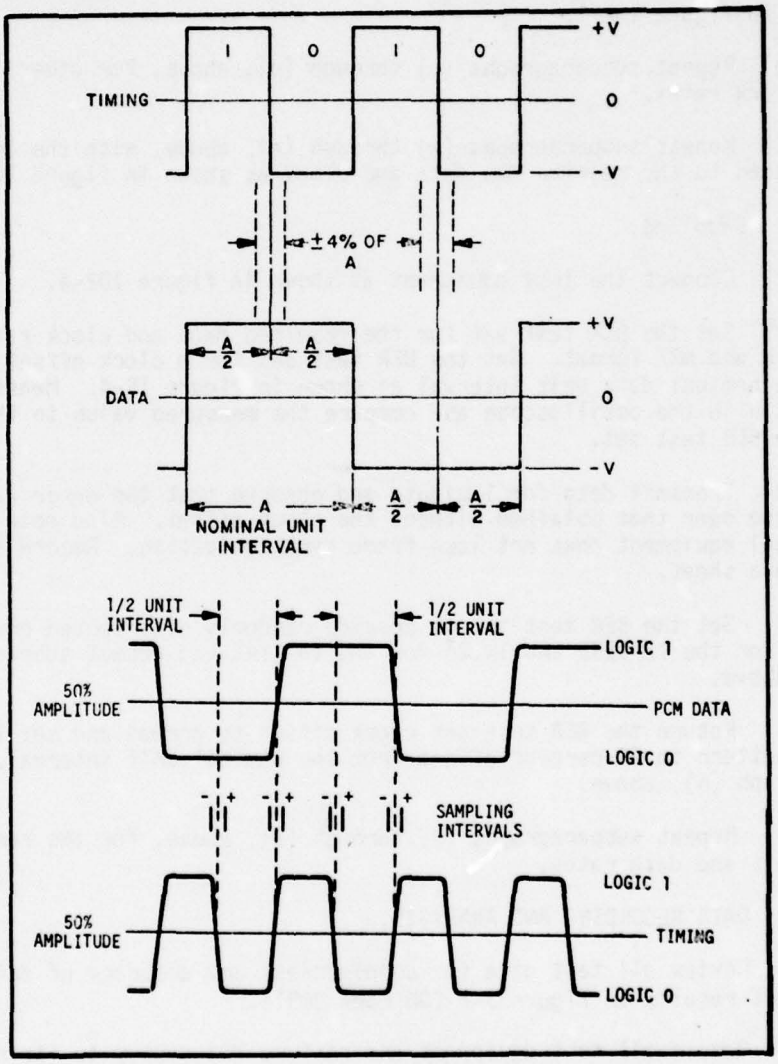


Figure 102-1. Typical waveforms of phasing (data and timing relationship--trailing edge).

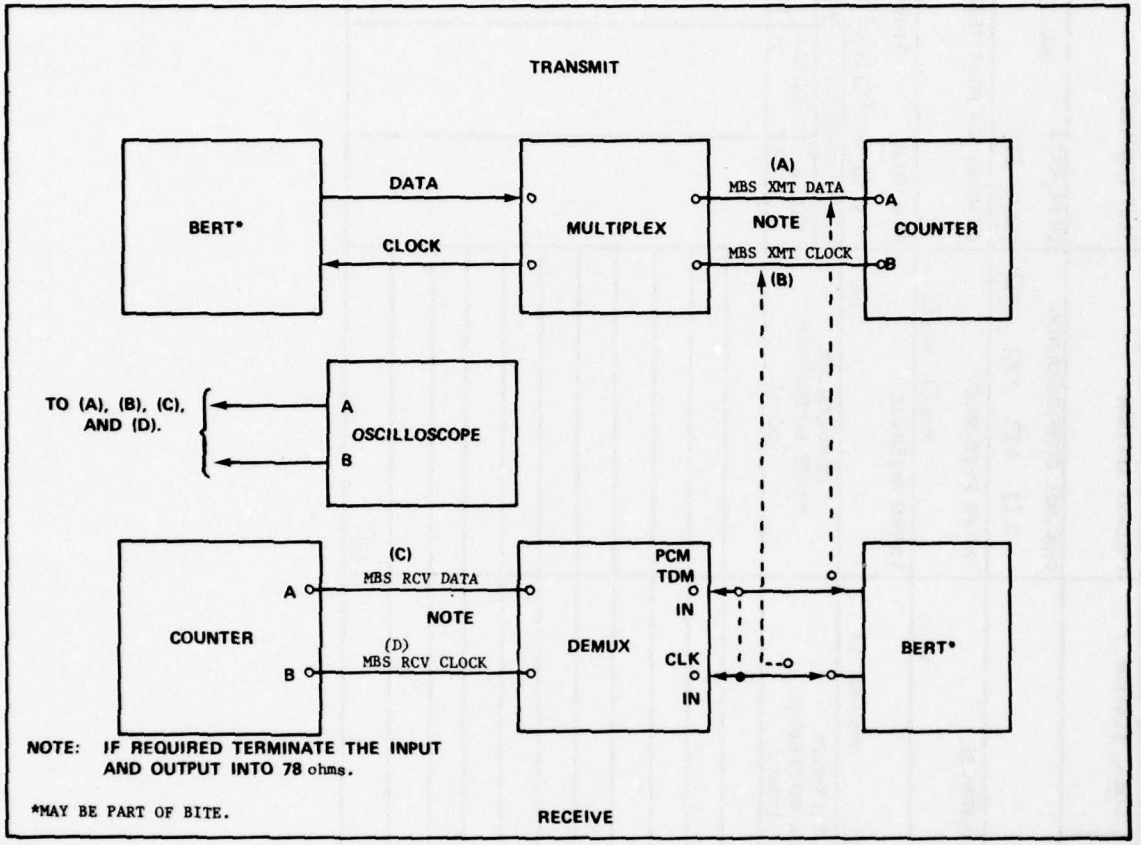


Figure 102-2. Phasing (PCM data and timing) test setup.

CCP 702-11

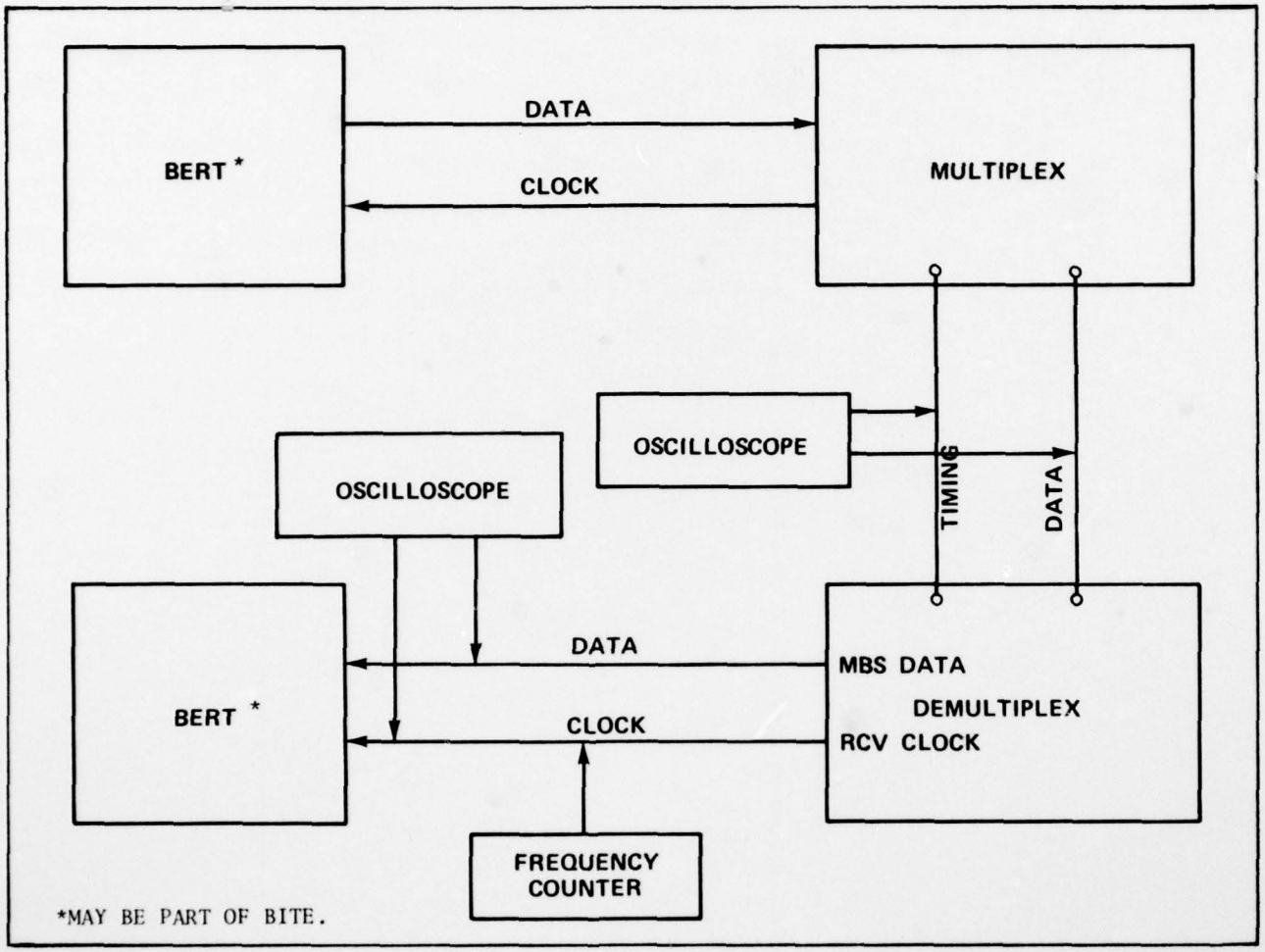
DATA AND TIMING PHASING AND SAMPLING (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		CHANNEL CONFIGURATION 3 ☐ 6 ☐ 12 ☐ 24 ☐	DATA RATE (kb/s ☐) (mb/s ☐)
DATA UNIT INTERVAL µsec		TIMING FREQUENCY MHz ☐ kHz ☐	CHANNEL OR PORT TESTED
FORMAT NRZ ☐ BIPOLAR ☐		TIMING INTERVAL µsec	BER USED OTHER ☐ 0 ☐ 1×10^{2} ☐ 1×10^{3} ☐

MULTIPLEX PHASE DIFFERENCE (nsec)	DEMULTIPLEX PHASE DIFFERENCE (nsec)	OFFSET CLOCK %	OFFSET DATA %	SYNC LOST YES	SYNC LOST NO
AVG	AVG				

COMMENTS

USACC FORM 673-R
1 MAY 79

Figure 102-3. Data and timing phasing and sampling data sheet.



CCP 702-11

Figure 102-4. Sampling internal test setup.

CHAPTER 103

EXTERNAL TIMING SOURCE AND RECEIVE TIMING OUTPUT (DT-300)

103-1. GENERAL.

a. The purpose of this test is to verify:

(1) Transmit output master clock frequency.

(2) Recovered receive timing output.

(3) Ability of the terminal to operate with an external master clock and to automatically switch to the internal clock upon loss of the external signal.

b. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

c. This test may be performed in conjunction with DT-292, DT-296, and DT-297. These particular tests demonstrate the timing and data characteristics as shown in tables 95-1 and 64-2.

103-2. SPECIFICATIONS.

a. The multiplex/demultiplex equipment shall operate in accordance with paragraph 4.3.1.6 of MIL-STD-188-100.

b. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) The multiplexer shall operate from an external source which is at the timing rate of the specific mode of operation of the multiplex terminal (table 95-1). The timing input shall be square wave and shall meet the timing requirements listed in table 64-2. The stability of the external timing source shall be equal to or better than the multiplex terminal's internal timing. In the event the external source is lost, the multiplex terminal shall automatically switch to the internal oscillator. In addition to all other timing outputs required, the multiplex terminal shall provide its internal master oscillator output through an external connector and shall meet the timing requirements shown in table 64-2.

(2) Provisions shall be included in the demultiplexer to provide recovered receive timing as an output through a connector and shall meet the square wave timing requirements as shown in table 64-2.

c. The following criteria applies to the TD-1193. (CCC-74048)

(1) The multiplexer portion of the TDM shall operate from an external source which is at the timing rate of the TDM as shown in table 95-3. The

timing input signal shall be square wave and shall meet the requirements contained in table 95-3. The stability of the external timing source shall be equal to or better than the TDM's internal timing. In the event the external source is lost, the TDM shall automatically switch to the internal oscillator. In addition to all other timing requirements, the TDM shall provide its internal master oscillator as an output through an external connector and shall meet the interface requirements of table 64-2.

(2) Provisions shall be included in the demultiplexer to provide the received timing as an output through a connector.

d. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

103-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Function generator.

c. Frequency counter.

d. Oscilloscope.

e. Cables, connectors, and terminations, as required.

103-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 103-1 and allow approximately 30 minutes for warmup and stabilization.

b. Set up the BER test set to correspond to the data rate and timing of the unit under test. Initially connect the multiplex for internal timing operation with the multiplexer/demultiplexer supplying timing to the BER test set.

c. Set the function generator to the frequency and output level for the unit under test as shown in table 95-1 or 95-3.

d. Transmit data from the BER test set for 5 minutes and note that the received data is error free. Measure and record the multiplexer master oscillator output frequency with the frequency counter at the master oscillator output connector.

e. At the receive demultiplexer, measure and record the recovered receive timing at the timing output connector. Record the results on figure 103-2 (USACC Form 674-R).

f. With the oscilloscope, measure the rise and fall times, ringing, and phasing of the data and timing signal as described in DT-296, DT-297, and DT-299, if not previously performed.

g. On the transmit multiplex, switch the unit to the external timing position. In this case, the function generator will be providing the timing to the equipment under test.

NOTE: If the function generator impedance does not match the equipment timing input, use an impedance matching network.

h. Repeat subparagraphs d, e, and f, above.

i. Disconnect the function gnerator and observe that the multiplexer automatically switches to its internal timing source.

j. Repeat subparagraphs a through i, above, for each mode of operation as shown in tables 95-1 and 95-3. Record the results on the data sheet.

103-5. DATA RECORDING AND ANALYSIS.

a. Review all data for compliance with the stated requirements and summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

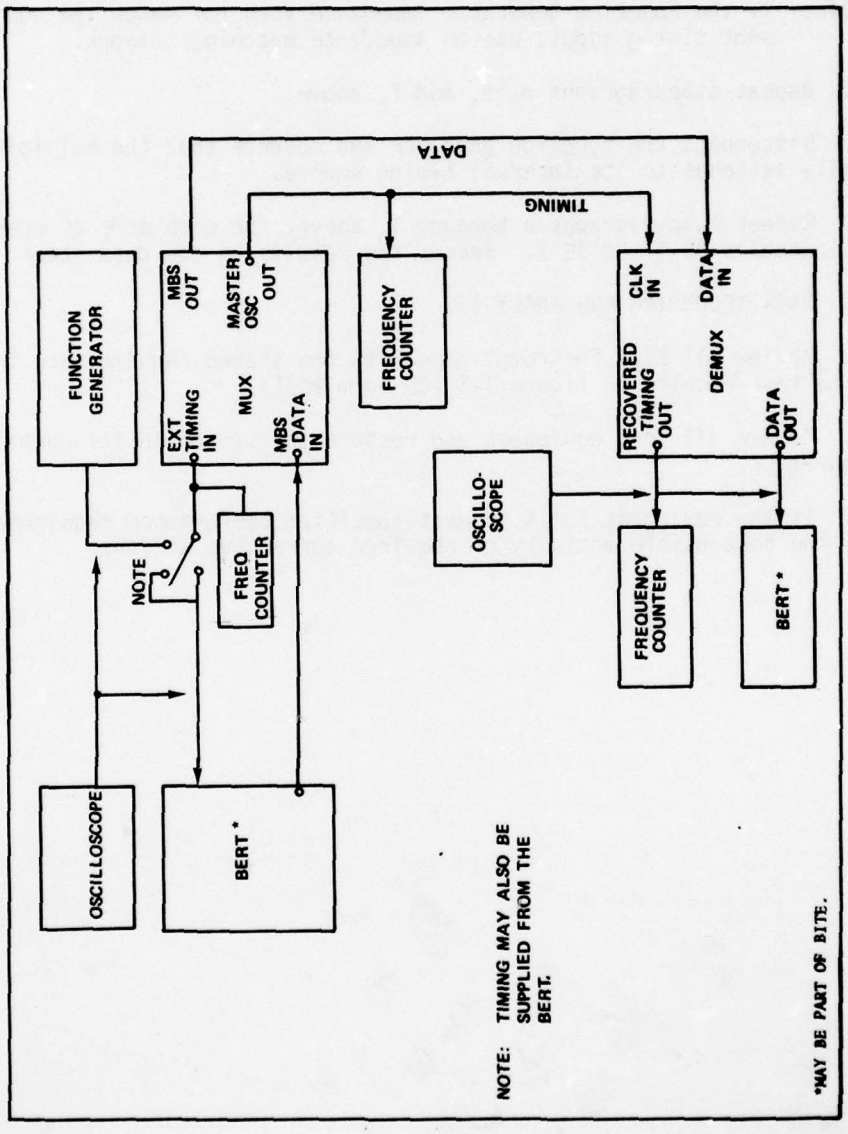


Figure 103-1. External timing source and receive timing output test setup.

EXTERNAL/INTERNAL TIMING FREQUENCY
(CCR 702-1-3)

DATA SHEET

PAGE OF PAGES

DATE (DAY, MO, YEAR)

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

EQUIPMENT	MODE OF OPERATION	DATA RATE
		mb/s

TIMING FREQUENCY	FORMAT	CHANNEL OR PORT
MHz	NRZ ☐ BIPOLAR ☐	

PARAMETER	FREQUENCY (MHz)	TERMN VOLTAGE (VPP)	OPEN CKT VOLTS (VPP)	RISE & FALL TIMES (nsec) 10%	RISE & FALL TIME (nsec) 90%	RING-ING (%)	BER CLK	BER EXT CLK
XMT INTERNAL CLOCK								
XMT EXTERNAL CLOCK								
RECOVERED RCV TIMING								

NOMINAL DATA UNIT INTERVAL μsec

NOMINAL TIMING PULSE WIDTH μsec

COMMENTS:

USACC FORM 674-R
1 MAY 79

Figure 103-2. External/internal timing frequency data sheet.

CHAPTER 104

COMBINED EFFECTS OF JITTER (DT-301)

104-1. GENERAL.

a. The purpose of this test is to determine the multiplexer/demultiplexer performance when the data and timing inputs have a specified level of phase jitter.

b. This test consists primarily of inserting a known amount of jitter on the data and timing inputs of the multiplexer/demultiplexer and comparing the BER performance with and without the jitter. This will verify the amount of jitter that can be tolerated before signal degradation occurs.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

104-2. SPECIFICATIONS.

a. The TD-1192 (AN/FCC-98) multiplex terminal shall operate properly with digital NRZ data and timing inputs each having jitter equal to as much as 12.5 percent of the data unit interval or a peak timing to peak data excursion of 25 percent of the data unit interval. (CCC-74047)

b. The TD-1193 shall conform to the requirements stated above for the TD-1192. (CCC-74048)

c. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

104-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Function generator.

c. Oscilloscope.

d. Phase jitter meter.

e. Jitter generator.

f. Digital printer.

104-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 104-1 and allow approximately 30 minutes for warmup and stabilization.

b. Initially connect the BER test set to the multiplexer as shown by dotted lines on figure 104-1. Set the BER test set output data rate, level, and impedance to correspond to the test point being used. Set the signal format for NRZ operation.

c. Transmit data for 5 minutes while recording any errors, clock loss, clock slip, or other pertinent data at the demultiplexer. Record the average number of errors on figure 104-2 (USACC Form 675-R). This will establish the baseline performance for the procedures that follow.

d. Connect the function generator output to the jitter generator clock input and to the BER test set clock input through a T-connector. Connect the BER test set data output to the data input connector of the jitter generator as shown in figure 104-1. Adjust the BER test set and function generator for the appropriate data rate for the unit under test as shown in tables 95-1, 64-2, or 95-3, as applicable.

e. Connect the multiplexer for external clock input and NRZ format. Adjust the jitter generator modulation rate and level for 12.5 percent of the nominal data unit interval as read on the phase jitter meter. Refer to DT-300 for the data and timing unit interval. Adjust the jitter generator noise frequency and level as required with zero delay of the data and timing signals.

f. At the multiplexer, transmit a 1010 pattern or other appropriate random word sequence. At the receive demultiplexer, measure and record the jitter of the receive data and recovered clock.

g. At the multiplexer, continue transmitting data with 12.5 percent of jitter. At the receive demultiplexer, record the BER for a 5-minute period. Record the average BER on the data sheet and compare this value with the value established in subparagraph c, above.

h. Repeat subparagraphs b through g, above, for other data and timing rates for each channel/port input. Repeat subparagraphs b through g, above, with the jitter generator providing up to 25-percent peak timing to peak data excursion of the data unit interval.

i. If directed, adjust the jitter generator for data offsets of 10 and 90 percent. Measure the BER performance at the receive demultiplexer.

j. Record all test results on the data sheet.

104-5. DATA RECORDING AND ANALYSIS.

a. Review all data for compliance with the stated requirements and summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

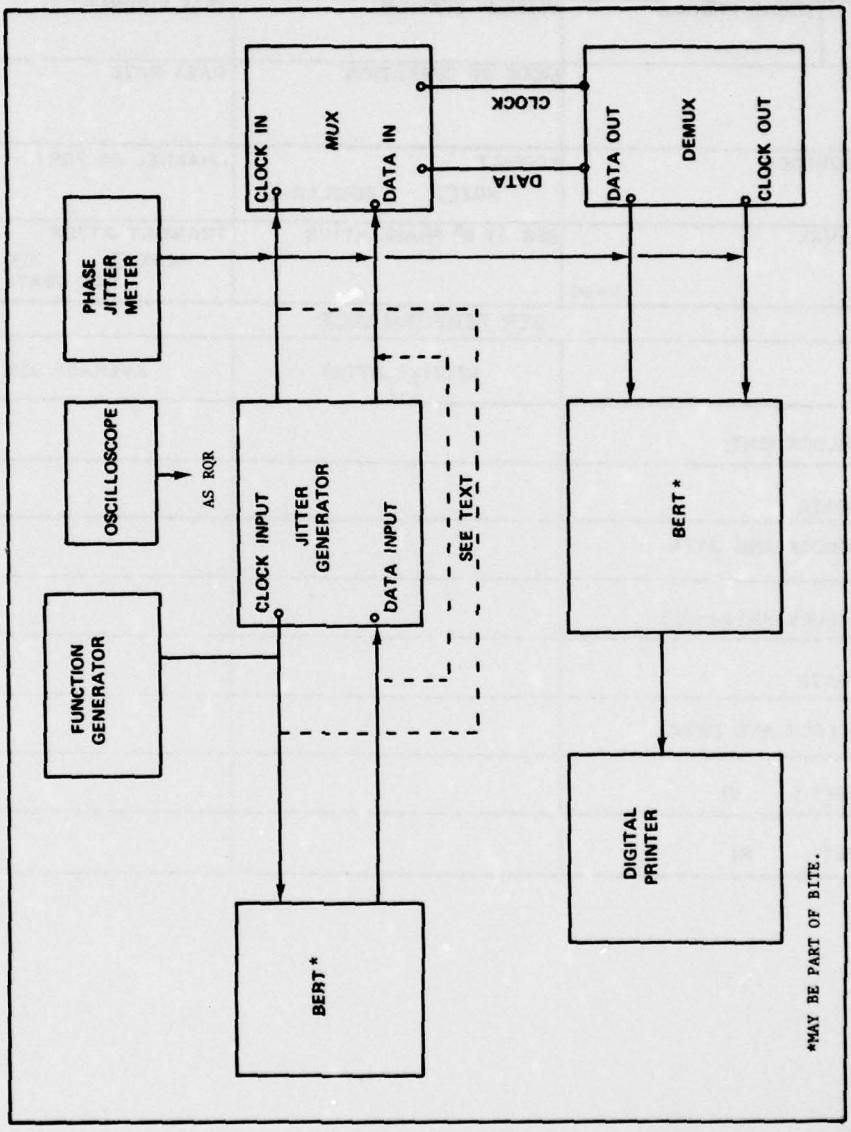


Figure 104-1. Combined effects of jitter test setup.

COMBINED EFFECTS OF JITTER (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		MODE OF OPERATION	DATA RATE mb/s
TIMING FREQUENCY		FORMAT NRZ ☐ BIPOLAR ☐	CHANNEL OR PORT
DATA INTERVAL μsec		BER AT 0° PHASE JITTER	TRANSMIT JITTER 12.5% ☐ 25% ☐ (SEE TEXT)

BER PERFORMANCE		
PARAMETER	RECEIVE JITTER (UI)	AVERAGE BER
TRANSMIT CLOCK (EXT)		
TRANSMIT DATA		
TRANSMIT CLOCK AND DATA		
TRANSMIT CLOCK (INTERNAL)		
TRANSMIT DATA		
TRANSMIT CLOCK AND DATA		
CLOCK OFFSET (%)		
DATA OFFSET (%)		
COMMENTS		

USACC FORM 675-R
1 MAY 79

Figure 104-2. Combined effects of jitter data sheet.

CHAPTER 105

TD-1192 (AN/FCC-98) AND TD-1193 MONITOR AND ALARMS (DT-302)

105-1. GENERAL.

a. The purpose of this test is to demonstrate and verify the proper operation of the equipment monitor and alarm functions.

b. This test may be performed on contractor EF&I systems to verify that their monitor and alarm operation conforms to specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

c. This test should be performed in conjuction with DT-274 and DT-275.

105-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) The multiplex terminal shall provide the following monitor and alarm functions. A contact closure as described in subparagraph (2), below, shall be provided for each alarm as well as a visual indicator for each alarm condition.

(a) *Power supply monitor and alarm.* A visual indicator lamp shall be provided on the front of the power supply to indicate primary AC or DC power has been applied. In the event primary power is lost or the protective device fails, the indicator lamp shall be extinguished and a remote alarm shall be provided.

(b) *Loss of frame alarm (demultiplexer only).* When the demultiplexer is either not in frame or timing to the framing circuitry fails, a red light shall operate. Alarm operation shall be such that, if the multiplex terminal reacquires frame synchronization, the red light will be deactivated. A remote alarm closure shall be provided.

(c) *Loss of output alarm (multiplexer only).* A red light shall operate when the multiplexer fails to either transmit data or timing (no transitions for nominally 100 msec or more). Alarm operation shall be such that if the multiplexer transmits data and timing, the red light shall be deactivated. A remote alarm closure shall be provided.

(d) *Loss of input alarm (demultiplexer only).* A red light shall operate when the demultiplexer fails to receive either data or timing (no transitions for nominally 100 msec or more). Alarm operation shall be such that if the demultiplexer receives data and timing, the red light shall be deactivated. A remote alarm closure shall be provided.

(e) *Loopback alarm.* Refer to DT-274.

(f) *Carrier group alarm.* Refer to DT-275.

(g) *Fault alarm.* A remote alarm closure shall activate and a red light shall operate when any failure of the multiplex terminal is detected by the BITE. Refer to DT-304 for verification of the BITE functions.

(h) *Frame error monitor.* The framing bits in the data input to the demultiplexer shall be monitored for errors. A pulse shall be provided at a connector on the multiplex terminal when each error occurs. Source impedance shall be 78 ohms ±10 percent (unbalanced). The signal shall be 1 volt ±10 percent square pulses with nominal pulse duration equal to the data unit interval of the specific mode of operation.

(2) Separate form C contacts isolated from ground and capable of carrying 1 ampere continuously shall be used to remote each alarm. The normally open, normally closed, and common contacts shall be provided at a connector on the multiplex terminal.

b. The following criteria applies to the TD-1193. (CCC-74048)

(1) The TDM shall provide the following monitor and alarms. A contact closure as described in subparagraph (2), below, shall be provided as specified. These indicators shall be visible with all panels attached and the doors closed when in a normal operation configuration.

(a) *Power supply monitor and alarm.* A visual indicator shall be provided on the front of the power supply to indicate primary AC or DC power has been applied. In the event primary power is lost or the protective device fails, the indicator shall be extinguished and a remote alarm closure shall be provided.

(b) *Loss of frame alarm.* When the demultiplexer is either not in frame or timing to the framing circuitry fails, a red light shall operate. Alarm operation shall be such that if the demultiplexer reacquires frame synchronization, the red light will be deactivated. A remote alarm closure shall be provided.

(c) *Loss of MBS output alarm.* A red light shall operate when the TDM fails to transmit either MBS data or MBS timing (no transitions for nominally 100 msec or more). Alarm operations shall be such that if the TDM transmits MBS data and MBS timing, the red light will be deactivated. A remote alarm closure shall be provided.

(d) *Loss of MBS input alarm.* A red light shall operate when the TDM fails to receive either MBS data or MBS timing (no transitions for nominally 100 msec or more). Alarm operations shall be such that if the TDM receives MBS data and MBS timing, the red light shall be deactivated. A remote alarm closure shall be provided.

(e) *Loss of port alarm.* A red light shall operate when any TDM port fails (loss of digital signal - no transitions for 100 msec or more) to output digital signals to the common equipment or output a digital signal to the port output connector. A separate remote alarm shall be provided for each of the two groups of multiplexer ports and each of the two groups of demultiplexer ports (a total of four remote alarms).

(f) *Fault alarm.* A remote alarm closure shall activate and a red light shall operate when any failure of the TDM is detected by the BITE as described in DT-304. Alarm operation shall be such that once the fault(s) is(are) corrected, the red light shall be deactivated.

(g) *Switchover monitor and alarm.* Indicator lights shall be provided to show: which multiplexer/demultiplexer is on-line (main or standby); the occurrence of any detected failure of the standby multiplexer/demultiplexer; whether the switching action was manually, remotely, or automatically initiated. Remote alarm contact closures shall be provided for each of the above functions.

(h) *Loopback and loopback alarm.* (Refer to DT-274.)

(2) A separate form C contact isolated from ground and capable of carrying 1 ampere continuously shall be used to remote each alarm. The normally open, normally closed, and common contacts shall be provided at a connector on the TDM.

105-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Oscilloscope.

c. Voltohmmeter.

105-4. TEST PROCEDURES. (Refer to figures 105-1 and 105-2.)

a. Power Supply Monitor and Alarms.

(1) Turn on the multiplex terminal equipment. Observe that a visual indicator on the power supply illuminates indicating power has been applied.

(2) Connect an ohmmeter to the external connector relay contact (fig. 105-3). Measure for continuity between the common contact and the normally open/closed contacts with power applied and denergized.

(3) Measure the condition of the normally open contacts of the external alarm contacts at the external connector.

b. Loss of Frame Alarm (Demultiplexer Only).

(1) Connect an ohmmeter to the external relay contacts and measure for continuity between the common contact and the normally open/closed contacts with power applied to the demultiplexer.

(2) Temporarily remove the input cable to the demultiplexer and observe that a loss of frame alarm light activates. With the ohmmeter connected as outlined in paragraph 105-4b(1), verify that the external relay contacts change state.

NOTE: Additional alarm indicators such as loss of data input and synchronization will also be present when the input is removed.

(3) Restore the cable and verify that all alarms extinguish.

(4) At the transmit end, remove the timing signal to the demultiplexer. At the receive end, verify that the loss of frame, loss of timing, and loss of synchronization alarm lights activate. Also observe on the ohmmeter that the relay contacts change state.

(5) Restore the transmit timing signal and observe that all alarms extinguish. Record the results on figure 105-4 (USACC Form 676-R)

c. Loss of Output Alarm (Multiplexer Only).

(1) Connect the test equipment as shown in figure 105-3 with the BER test set connected to one of the data channels or data input ports.

(2) Connect an ohmmeter to the external loss of output and common contact. Measure the loss of output and verify that the normally open contacts are open.

(3) Set the oscilloscope differential amplifier to positive (+) DC, 1 volt per division. Set the time base trigger to internal and adjust the time base to view an 8-bit pattern of the transmit data.

(4) Set the BER test set pattern generator to provide a 11111111 input pattern. Adjust the oscilloscope to verify the transmitted data pattern.

(5) Connect the oscilloscope differential amplifier to one of the data channels/ports (data output). Set the oscilloscope differential amplifier for 0.1 msec per division.

(6) Verify a 11111111 pattern on the oscilloscope. Record the elapsed time from the time of no transition until an alarm condition is observed.

(7) With the ohmmeter, measure from the common relay contact to the normally closed contact and verify that the contacts are open. Also observe and record that an MBS input alarm light activates when the BER test set does not provide data transition input.

d. Loss of Input Alarm (Demultiplexer Only).

(1) Temporarily remove the MBS input patch cable to the demultiplexer. Verify that the carrier group alarm, frame loss, and output loss indicators illuminate. Verify that the external normally open/closed contacts of the external alarm circuits activate. Record the results on the data sheet.

(2) Set the pattern generator and oscillocope as in subparagraph c, above. Measure and record the time for the input alarm to activate from the pattern received on the oscilloscope. Record the results on the data sheet.

e. Fault Alarm. Verify that the fault alarm light on the BITE illuminates and the normally open contacts of the fault alarm relay activate for each of the alarm conditons shown in tables 105-1 and 105-2. Record all results on the data sheet.

f. Frame Error Monitor. Connect the oscilloscope differential amplifier to the equipment frame error test point. Remove the MBS receive clock patch cable and observe the pulses at TP-3. Note and observe that a frame error lamp illuminates and that the normally closed relay contacts activate. Record the results on the data sheet.

NOTE: The voltage level and impedance at the frame monitor external connector were measured in a preceding test.

g. The following (switchover monitor and alarm) pertains only to the TD-1193 as reflected in paragraph 105-2.

(1) With the main multiplexer on-line, observe that the indicator on the main terminal illuminates and the standby unit indicator lamp extinguishes. With the ohmmeter, verify the status of the external relay contacts.

(2) Manually switch the main unit off-line and the standby unit on-line. Verify that the standby unit lamp illuminates indicating an on-line condition and the external relay contacts change state.

(3) Place the standby unit off-line and the main unit on-line. Turn off the AC/DC input power to the standby unit and observe that the alarm lamp activates and the external relay contacts change state indicating a failure in the standby unit. Restore the power input to the standby unit and observe that the alarm lamp extinguishes and the relay contacts change state. Introduce a fault in the standby unit by temporarily removing a port module. Note that a fault alarm activates and the external relay contacts change state. Repeat the above with the main terminal equipment functioning as the standby unit. Record all results on the data sheet.

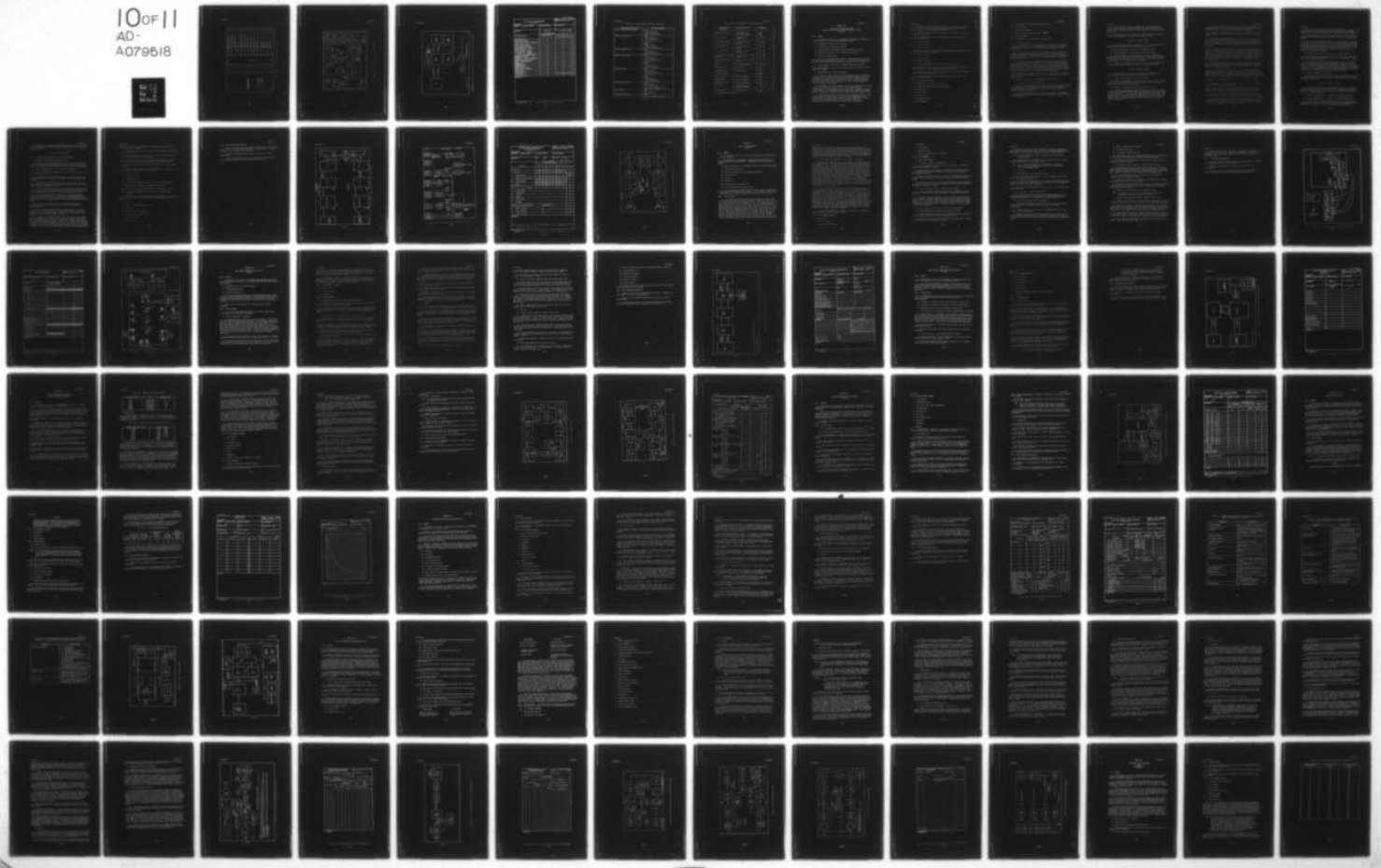
105-5. DATA RECORDING AND ANALYSIS.

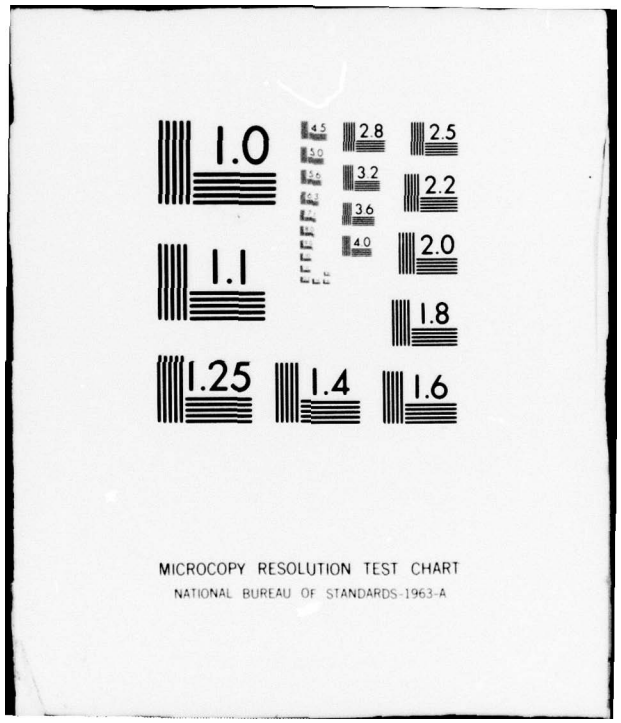
a. Record all data on figure 105-4 (USACC Form 676-R). Summarize the test results on figure 3-7 (DD Form 2091).

b. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL

10 OF 11
AD-
A079518




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
7.1
8.0
9.0
10
11
12
14
16
18
20
22
25
28
32
36
40
45
50
56
63
71
80
90
100
110
125
140
160
180
200
220
250
280
320
360
400
450
500
560
630
710
800
900
1000
1100
1250
1400
1600
1800
2000
2200
2500
2800
3200
3600
4000
4500
5000
5600
6300
7100
8000
9000
10000
11000
12500
14000
16000
18000
20000
22000
25000
28000
32000
36000
40000
45000
50000
56000
63000
71000
80000
90000
100000
110000
125000
140000
160000
180000
200000
220000
250000
280000
320000
360000
400000
450000
500000
560000
630000
710000
800000
900000
1000000
1100000
1250000
1400000
1600000
1800000
2000000
2200000
2500000
2800000
3200000
3600000
4000000
4500000
5000000
5600000
6300000
7100000
8000000
9000000
10000000
11000000
12500000
14000000
16000000
18000000
20000000
22000000
25000000
28000000
32000000
36000000
40000000
45000000
50000000
56000000
63000000
71000000
80000000
90000000
100000000
110000000
125000000
140000000
160000000
180000000
200000000
220000000
250000000
280000000
320000000
360000000
400000000
450000000
500000000
560000000
630000000
710000000
800000000
900000000
1000000000
1100000000
1250000000
1400000000
1600000000
1800000000
2000000000
2200000000
2500000000
2800000000
3200000000
3600000000
4000000000
4500000000
5000000000
5600000000
6300000000
7100000000
8000000000
9000000000
10000000000
11000000000
12500000000
14000000000
16000000000
18000000000
20000000000
22000000000
25000000000
28000000000
32000000000
36000000000
40000000000
45000000000
50000000000
56000000000
63000000000
71000000000
80000000000
90000000000
100000000000
110000000000
125000000000
140000000000
160000000000
180000000000
200000000000
220000000000
250000000000
280000000000
320000000000
360000000000
400000000000
450000000000
500000000000
560000000000
630000000000
710000000000
800000000000
900000000000
1000000000000
1100000000000
1250000000000
1400000000000
1600000000000
1800000000000
2000000000000
2200000000000
2500000000000
2800000000000
3200000000000
3600000000000
4000000000000
4500000000000
5000000000000
5600000000000
6300000000000
7100000000000
8000000000000
9000000000000
10000000000000
11000000000000
12500000000000
14000000000000
16000000000000
18000000000000
20000000000000
22000000000000
25000000000000
28000000000000
32000000000000
36000000000000
40000000000000
45000000000000
50000000000000
56000000000000
63000000000000
71000000000000
80000000000000
90000000000000
100000000000000
110000000000000
125000000000000
140000000000000
160000000000000
180000000000000
200000000000000
220000000000000
250000000000000
280000000000000
320000000000000
360000000000000
400000000000000
450000000000000
500000000000000
560000000000000
630000000000000
710000000000000
800000000000000
900000000000000
1000000000000000
1100000000000000
1250000000000000
1400000000000000
1600000000000000
1800000000000000
2000000000000000
2200000000000000
2500000000000000
2800000000000000
3200000000000000
3600000000000000
4000000000000000
4500000000000000
5000000000000000
5600000000000000
6300000000000000
7100000000000000
8000000000000000
9000000000000000
10000000000000000
11000000000000000
12500000000000000
14000000000000000
16000000000000000
18000000000000000
20000000000000000
22000000000000000
25000000000000000
28000000000000000
32000000000000000
36000000000000000
40000000000000000
45000000000000000
50000000000000000
56000000000000000
63000000000000000
71000000000000000
80000000000000000
90000000000000000
100000000000000000
110000000000000000
125000000000000000
140000000000000000
160000000000000000
180000000000000000
200000000000000000
220000000000000000
250000000000000000
280000000000000000
320000000000000000
360000000000000000
400000000000000000
450000000000000000
500000000000000000
560000000000000000
630000000000000000
710000000000000000
800000000000000000
900000000000000000
1000000000000000000
1100000000000000000
1250000000000000000
1400000000000000000
1600000000000000000
1800000000000000000
2000000000000000000
2200000000000000000
2500000000000000000
2800000000000000000
3200000000000000000
3600000000000000000
4000000000000000000
4500000000000000000
5000000000000000000
5600000000000000000
6300000000000000000
7100000000000000000
8000000000000000000
9000000000000000000
10000000000000000000
11000000000000000000
12500000000000000000
14000000000000000000
16000000000000000000
18000000000000000000
20000000000000000000
22000000000000000000
25000000000000000000
28000000000000000000
32000000000000000000
36000000000000000000
40000000000000000000
45000000000000000000
50000000000000000000
56000000000000000000
63000000000000000000
71000000000000000000
80000000000000000000
90000000000000000000
100000000000000000000
110000000000000000000
125000000000000000000
140000000000000000000
160000000000000000000
180000000000000000000
200000000000000000000
220000000000000000000
250000000000000000000
280000000000000000000
320000000000000000000
360000000000000000000
400000000000000000000
450000000000000000000
500000000000000000000
560000000000000000000
630000000000000000000
710000000000000000000
800000000000000000000
900000000000000000000
1000000000000000000000
1100000000000000000000
1250000000000000000000
1400000000000000000000
1600000000000000000000
1800000000000000000000
2000000000000000000000
2200000000000000000000
2500000000000000000000
2800000000000000000000
3200000000000000000000
3600000000000000000000
4000000000000000000000
4500000000000000000000
5000000000000000000000
5600000000000000000000
6300000000000000000000
7100000000000000000000
8000000000000000000000
9000000000000000000000
10000000000000000000000
11000000000000000000000
12500000000000000000000
14000000000000000000000
16000000000000000000000
18000000000000000000000
20000000000000000000000
22000000000000000000000
25000000000000000000000
28000000000000000000000
32000000000000000000000
36000000000000000000000
40000000000000000000000
45000000000000000000000
50000000000000000000000
56000000000000000000000
63000000000000000000000
71000000000000000000000
80000000000000000000000
90000000000000000000000
100000000000000000000000
110000000000000000000000
125000000000000000000000
140000000000000000000000
160000000000000000000000
180000000000000000000000
200000000000000000000000
220000000000000000000000
250000000000000000000000
280000000000000000000000
320000000000000000000000
360000000000000000000000
400000000000000000000000
450000000000000000000000
500000000000000000000000
560000000000000000000000
630000000000000000000000
710000000000000000000000
800000000000000000000000
900000000000000000000000
1000000000000000000000000
1100000000000000000000000
1250000000000000000000000
1400000000000000000000000
1600000000000000000000000
1800000000000000000000000
2000000000000000000000000
2200000000000000000000000
2500000000000000000000000
2800000000000000000000000
3200000000000000000000000
3600000000000000000000000
4000000000000000000000000
4500000000000000000000000
5000000000000000000000000
5600000000000000000000000
6300000000000000000000000
7100000000000000000000000
8000000000000000000000000
9000000000000000000000000
10000000000000000000000000
11000000000000000000000000
12500000000000000000000000
14000000000000000000000000
16000000000000000000000000
18000000000000000000000000
20000000000000000000000000
22000000000000000000000000
25000000000000000000000000
28000000000000000000000000
32000000000000000000000000
36000000000000000000000000
40000000000000000000000000
45000000000000000000000000
50000000000000000000000000
56000000000000000000000000
63000000000000000000000000
71000000000000000000000000
80000000000000000000000000
90000000000000000000000000
100000000000000000000000000
110000000000000000000000000
125000000000000000000000000
140000000000000000000000000
160000000000000000000000000
180000000000000000000000000
200000000000000000000000000
220000000000000000000000000
250000000000000000000000000
280000000000000000000000000
320000000000000000000000000
360000000000000000000000000
400000000000000000000000000
450000000000000000000000000
500000000000000000000000000
560000000000000000000000000
630000000000000000000000000
710000000000000000000000000
800000000000000000000000000
900000000000000000000000000
1000000000000000000000000000
1100000000000000000000000000
1250000000000000000000000000
1400000000000000000000000000
1600000000000000000000000000
1800000000000000000000000000
2000000000000000000000000000
2200000000000000000000000000
2500000000000000000000000000
2800000000000000000000000000
3200000000000000000000000000
3600000000000000000000000000
4000000000000000000000000000
4500000000000000000000000000
5000000000000000000000000000
5600000000000000000000000000
6300000000000000000000000000
7100000000000000000000000000
8000000000000000000000000000
9000000000000000000000000000
10000000000000000000000000000
11000000000000000000000000000
12500000000000000000000000000
14000000000000000000000000000
16000000000000000000000000000
18000000000000000000000000000
20000000000000000000000000000
22000000000000000000000000000
25000000000000000000000000000
28000000000000000000000000000
32000000000000000000000000000
36000000000000000000000000000
40000000000000000000000000000
45000000000000000000000000000
50000000000000000000000000000
56000000000000000000000000000
63000000000000000000000000000
71000000000000000000000000000
80000000000000000000000000000
90000000000000000000000000000
100000000000000000000000000000
110000000000000000000000000000
125000000000000000000000000000
140000000000000000000000000000
160000000000000000000000000000
180000000000000000000000000000
200000000000000000000000000000
220000000000000000000000000000
250000000000000000000000000000
280000000000000000000000000000
320000000000000000000000000000
360000000000000000000000000000
400000000000000000000000000000
450000000000000000000000000000
500000000000000000000000000000
560000000000000000000000000000
630000000000000000000000000000
710000000000000000000000000000
800000000000000000000000000000
900000000000000000000000000000
1000000000000000000000000000000
1100000000000000000000000000000
1250000000000000000000000000000
1400000000000000000000000000000
1600000000000000000000000000000
1800000000000000000000000000000
2000000000000000000000000000000
2200000000000000000000000000000
2500000000000000000000000000000
2800000000000000000000000000000
3200000000000000000000000000000
3600000000000000000000000000000
4000000000000000000000000000000
4500000000000000000000000000000
5000000000000000000000000000000
5600000000000000000000000000000
6300000000000000000000000000000
7100000000000000000000000000000
8000000000000000000000000000000
9000000000000000000000000000000
10000000000000000000000000000000
11000000000000000000000000000000
12500000000000000000000000000000
14000000000000000000000000000000
16000000000000000000000000000000
18000000000000000000000000000000
20000000000000000000000000000000
22000000000000000000000000000000
25000000000000000000000000000000
28000000000000000000000000000000
32000000000000000000000000000000
36000000000000000000000000000000
40000000000000000000000000000000
45000000000000000000000000000000
50000000000000000000000000000000
56000000000000000000000000000000
63000000000000000000000000000000
71000000000000000000000000000000
80000000000000000000000000000000
90000000000000000000000000000000
100000000000000000000000000000000
110000000000000000000000000000000
125000000000000000000000000000000
140000000000000000000000000000000
160000000000000000000000000000000
180000000000000000000000000000000
200000000000000000000000000000000
220000000000000000000000000000000
250000000000000000000000000000000
280000000000000000000000000000000
320000000000000000000000000000000
360000000000000000000000000000000
400000000000000000000000000000000
450000000000000000000000000000000
500000000000000000000000000000000
560000000000000000000000000000000
630000000000000000000000000000000
710000000000000000000000000000000
800000000000000000000000000000000
900000000000000000000000000000000
1000000000000000000000000000000000
1100000000000000000000000000000000
1250000000000000000000000000000000
1400000000000000000000000000000000
1600000000000000000000000000000000
1800000000000000000000000000000000
2000000000000000000000000000000000
2200000000000000000000000000000000
2500000000000000000000000000000000
2800000000000000000000000000000000
3200000000000000000000000000000000
3600000000000000000000000000000000
4000000000000000000000000000000000
4500000000000000000000000000000000
5000000000000000000000000000000000
5600000000000000000000000000000000
6300000000000000000000000000000000
7100000000000000000000000000000000
8000000000000000000000000000000000
9000000000000000000000000000000000
10000000000000000000000000000000000
11000000000000000000000000000000000
12500000000000000000000000000000000
14000000000000000000000000000000000
16000000000000000000000000000000000
18000000000000000000000000000000000
20000000000000000000000000000000000
22000000000000000000000000000000000
25000000000000000000000000000000000
28000000000000000000000000000000000
32000000000000000000000000000000000
36000000000000000000000000000000000
40000000000000000000000000000000000
45000000000000000000000000000000000
50000000000000000000000000000000000
56000000000000000000000000000000000
63000000000000000000000000000000000
71000000000000000000000000000000000
80000000000000000000000000000000000
90000000000000000000000000000000000
100000000000000000000000000000000000
110000000000000000000000000000000000
125000000000000000000000000000000000
140000000000000000000000000000000000
160000000000000000000000000000000000
180000000000000000000000000000000000
200000000000000000000000000000000000
220000000000000000000000000000000000
250000000000000000000000000000000000
280000000000000000000000000000000000
320000000000000000000000000000000000
360000000000000000000000000000000000
400000000000000000000000000000000000
450000000000000000000000000000000000
500000000000000000000000000000000000
560000000000000000000000000000000000
630000000000000000000000000000000000
710000000000000000000000000000000000
800000000000000000000000000000000000
900000000000000000000000000000000000
1000000000000000000000000000000000000
1100000000000000000000000000000000000
1250000000000000000000000000000000000
1400000000000000000000000000000000000
1600000000000000000000000000000000000
1800000000000000000000000000000000000
2000000000000000000000000000000000000
2200000000000000000000000000000000000
2500000000000000000000000000000000000
2800000000000000000000000000000000000
3200000000000000000000000000000000000
3600000000000000000000000000000000000
4000000000000000000000000000000000000
4500000000000000000000000000000000000
5000000000000000000000000000000000000
5600000000000000000000000000000000000
6300000000000000000000000000000000000
7100000000000000000000000000000000000
8000000000000000000000000000000000000
9000000000000000000000000000000000000
10000000000000000000000000000000000000
11000000000000000000000000000000000000
12500000000000000000000000000000000000
14000000000000000000000000000000000000
16000000000000000000000000000000000000
18000000000000000000000000000000000000
20000000000000000000000000000000000000
22000000000000000000000000000000000000
25000000000000000000000000000000000000
28000000000000000000000000000000000000
32000000000000000000000000000000000000
36000000000000000000000000000000000000
40000000000000000000000000000000000000
45000000000000000000000000000000000000
50000000000000000000000000000000000000
56000000000000000000000000000000000000
63000000000000000000000000000000000000
71000000000000000000000000000000000000
80000000000000000000000000000000000000
90000000000000000000000000000000000000
100000000000000000000000000000000000000
110000000000000000000000000000000000000
125000000000000000000000000000000000000
140000000000000000000000000000000000000
160000000000000000000000000000000000000
180000000000000000000000000000000000000
200000000000000000000000000000000000000
220000000000000000000000000000000000000
250000000000000000000000000000000000000
280000000000000000000000000000000000000
320000000000000000000000000000000000000
360000000000000000000000000000000000000
400000000000000000000000000000000000000
450000000000000000000000000000000000000
500000000000000000000000000000000000000
560000000000000000000000000000000000000
630000000000000000000000000000000000000
710000000000000000000000000000000000000
800000000000000000000000000000000000000
900000000000000000000000000000000000000
1000000000000000000000000000000000000000
1100000000000000000000000000000000000000
1250000000000000000000000000000000000000
1400000000000000000000000000000000000000
1600000000000000000000000000000000000000
1800000000000000000000000000000000000000
2000000000000000000000000000000000000000
2200000000000000000000000000000000000000
2500000000000000000000000000000000000000
2800000000000000000000000000000000000000
3200000000000000000000000000000000000000
3600000000000000000000000000000000000000
4000000000000000000000000000000000000000
4500000000000000000000000000000000000000
5000000000000000000000000000000000000000
5600000000000000000000000000000000000000
6300000000000000000000000000000000000000
7100000000000000000000000000000000000000
8000000000000000000000000000000000000000
9000000000000000000000000000000000000000
10000000000000000000000000000000000000000
11000000000000000000000000000000000000000
12500000000000000000000000000000000000000
14000000000000000000000000000000000000000
16000000000000000000000000000000000000000
18000000000000000000000000000000000000000
20000000000000000000000000000000000000000
22000000000000000000000000000000000000000
25000000000000000000000000000000000000000
28000000000000000000000000000000000000000
32000000000000000000000000000000000000000
36000000000000000000000000000000000000000
40000000000000000000000000000000000000000
45000000000000000000000000000000000000000
50000000000000000000000000000000000000000
56000000000000000000000000000000000000000
63000000000000000000000000000000000000000
71000000000000000000000000000000000000000
80000000000000000000000000000000000000000
90000000000000000000000000000000000000000
100000000000000000000000000000000000000000
110000000000000000000000000000000000000000
125000000000000000000000000000000000000000
140000000000000000000000000000000000000000
160000000000000000000000000000000000000000
180000000000000000000000000000000000000000
200000000000000000000000000000000000000000
220000000000000000000000000000000000000000
250000000000000000000000000000000000000000
280000000000000000000000000000000000000000
320000000000000000000000000000000000000000
360000000000000000000000000000000000000000
400000000000000000000000000000000000000000
450000000000000000000000000000000000000000
500000000000000000000000000000000000000000
560000000000000000000000000000000000000000
630000000000000000000000000000000000000000
710000000000000000000000000000000000000000
800000000000000000000000000000000000000000
900000000000000000000000000000000000000000
1000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000
1250000000000000000000000000000000000000000
1400000000000000000000000000000000000000000
1600000000000000000000000000000000000000000
1800000000000000000000000000000000000000000
2000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000
2500000000000000000000000000000000000000000
2800000000000000000000000000000000000000000
3200000000000000000000000000000000000000000
3600000000000000000000000000000000000000000
4000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000
5000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000
6300000000000000000000000000000000000000000
7100000000000000000000000000000000000000000
8000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000
14000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000
50000000000000000000000000000000000000000000
56000000000000000000000000000000000000000000
63000000000000000000000000000000000000000000
71000000000000000000000000000000000000000000
80000000000000000000000000000000000000000000
90000000000000000000000000000000000000000000
100000000000000000000000000000000000000000000
110000000000000000000000000000000000000000000
125000000000000000000000000000000000000000000
140000000000000000000000000000000000000000000
160000000000000000000000000000000000000000000
180000000000000000000000000000000000000000000
200000000000000000000000000000000000000000000
220000000000000000000000000000000000000000000
250000000000000000000000000000000000000000000
280000000000000000000000000000000000000000000
320000000000000000000000000000000000000000000
360000000000000000000000000000000000000000000
400000000000000000000000000000000000000000000
450000000000000000000000000000000000000000000
500000000000000000000000000000000000000000000
560000000000000000000000000000000000000000000
630000000000000000000000000000000000000000000
710000000000000000000000000000000000000000000
800000000000000000000000000000000000000000000
900000000000000000000000000000000000000000000
1000000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000000
1250000000000000000000000000000000000000000000
1400000000000000000000000000000000000000000000
1600000000000000000000000000000000000000000000
1800000000000000000000000000000000000000000000
2000000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000000
2500000000000000000000000000000000000000000000
2800000000000000000000000000000000000000000000
3200000000000000000000000000000000000000000000
3600000000000000000000000000000000000000000000
4000000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000000
5000000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000000
6300000000000000000000000000000000000000000000
7100000000000000000000000000000000000000000000
8000000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000000
14000000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000000
50000000000000000000000000000000000000000000000
56000000000000000000000000000000000000000000000
63000000000000000000000000000000000000000000000
71000000000000000000000000000000000000000000000
80000000000000000000000000000000000000000000000
90000000000000000000000000000000000000000000000
100000000000000000000000000000000000000000000000
110000000000000000000000000000000000000000000000
125000000000000000000000000000000000000000000000
140000000000000000000000000000000000000000000000
160000000000000000000000000000000000000000000000
180000000000000000000000000000000000000000000000
200000000000000000000000000000000000000000000000
220000000000000000000000000000000000000000000000
250000000000000000000000000000000000000000000000
280000000000000000000000000000000000000000000000
320000000000000000000000000000000000000000000000
360000000000000000000000000000000000000000000000
400000000000000000000000000000000000000000000000
450000000000000000000000000000000000000000000000
500000000000000000000000000000000000000000000000
560000000000000000000000000000000000000000000000
630000000000000000000000000000000000000000000000
710000000000000000000000000000000000000000000000
800000000000000000000000000000000000000000000000
900000000000000000000000000000000000000000000000
1000000000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000000000
1250000000000000000000000000000000000000000000000
1400000000000000000000000000000000000000000000000
1600000000000000000000000000000000000000000000000
1800000000000000000000000000000000000000000000000
2000000000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000000000
2500000000000000000000000000000000000000000000000
2800000000000000000000000000000000000000000000000
3200000000000000000000000000000000000000000000000
3600000000000000000000000000000000000000000000000
4000000000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000000000
5000000000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000000000
6300000000000000000000000000000000000000000000000
7100000000000000000000000000000000000000000000000
8000000000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000000000
14000000000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000000000
50000000000000000000000000000000000000000000000000
56000000000000000000000000000000000000000000000000
63000000000000000000000000000000000000000000000000
71000000000000000000000000000000000000000000000000
80000000000000000000000000000000000000000000000000
90000000000000000000000000000000000000000000000000
100000000000000000000000000000000000000000000000000
110000000000000000000000000000000000000000000000000
125000000000000000000000000000000000000000000000000
140000000000000000000000000000000000000000000000000
160000000000000000000000000000000000000000000000000
180000000000000000000000000000000000000000000000000
200000000000000000000000000000000000000000000000000
220000000000000000000000000000000000000000000000000
250000000000000000000000000000000000000000000000000
280000000000000000000000000000000000000000000000000
320000000000000000000000000000000000000000000000000
360000000000000000000000000000000000000000000000000
400000000000000000000000000000000000000000000000000
450000000000000000000000000000000000000000000000000
500000000000000000000000000000000000000000000000000
560000000000000000000000000000000000000000000000000
630000000000000000000000000000000000000000000000000
710000000000000000000000000000000000000000000000000
800000000000000000000000000000000000000000000000000
900000000000000000000000000000000000000000000000000
1000000000000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000000000000
1250000000000000000000000000000000000000000000000000
1400000000000000000000000000000000000000000000000000
1600000000000000000000000000000000000000000000000000
1800000000000000000000000000000000000000000000000000
2000000000000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000000000000
2500000000000000000000000000000000000000000000000000
2800000000000000000000000000000000000000000000000000
3200000000000000000000000000000000000000000000000000
3600000000000000000000000000000000000000000000000000
4000000000000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000000000000
5000000000000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000000000000
6300000000000000000000000000000000000000000000000000
7100000000000000000000000000000000000000000000000000
8000000000000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000000000000
14000000000000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000000000000
50000000000000000000000000000000000000000000000000000
56000000000000000000000000000000000000000000000000000
63000000000000000000000000000000000000000000000000000
71000000000000000000000000000000000000000000000000000
80000000000000000000000000000000000000000000000000000
90000000000000000000000000000000000000000000000000000
100000000000000000000000000000000000000000000000000000
110000000000000000000000000000000000000000000000000000
125000000000000000000000000000000000000000000000000000
140000000000000000000000000000000000000000000000000000
160000000000000000000000000000000000000000000000000000
180000000000000000000000000000000000000000000000000000
200000000000000000000000000000000000000000000000000000
220000000000000000000000000000000000000000000000000000
250000000000000000000000000000000000000000000000000000
280000000000000000000000000000000000000000000000000000
320000000000000000000000000000000000000000000000000000
360000000000000000000000000000000000000000000000000000
400000000000000000000000000000000000000000000000000000
450000000000000000000000000000000000000000000000000000
500000000000000000000000000000000000000000000000000000
560000000000000000000000000000000000000000000000000000
630000000000000000000000000000000000000000000000000000
710000000000000000000000000000000000000000000000000000
800000000000000000000000000000000000000000000000000000
900000000000000000000000000000000000000000000000000000
1000000000000000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000000000000000
1250000000000000000000000000000000000000000000000000000
1400000000000000000000000000000000000000000000000000000
1600000000000000000000000000000000000000000000000000000
1800000000000000000000000000000000000000000000000000000
2000000000000000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000000000000000
2500000000000000000000000000000000000000000000000000000
2800000000000000000000000000000000000000000000000000000
3200000000000000000000000000000000000000000000000000000
3600000000000000000000000000000000000000000000000000000
4000000000000000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000000000000000
5000000000000000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000000000000000
6300000000000000000000000000000000000000000000000000000
7100000000000000000000000000000000000000000000000000000
8000000000000000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000000000000000
14000000000000000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000000000000000
50000000000000000000000000000000000000000000000000000000
56000000000000000000000000000000000000000000000000000000
63000000000000000000000000000000000000000000000000000000
71000000000000000000000000000000000000000000000000000000
80000000000000000000000000000000000000000000000000000000
90000000000000000000000000000000000000000000000000000000
100000000000000000000000000000000000000000000000000000000
110000000000000000000000000000000000000000000000000000000
125000000000000000000000000000000000000000000000000000000
140000000000000000000000000000000000000000000000000000000
160000000000000000000000000000000000000000000000000000000
180000000000000000000000000000000000000000000000000000000
200000000000000000000000000000000000000000000000000000000
220000000000000000000000000000000000000000000000000000000
250000000000000000000000000000000000000000000000000000000
280000000000000000000000000000000000000000000000000000000
320000000000000000000000000000000000000000000000000000000
360000000000000000000000000000000000000000000000000000000
400000000000000000000000000000000000000000000000000000000
450000000000000000000000000000000000000000000000000000000
500000000000000000000000000000000000000000000000000000000
560000000000000000000000000000000000000000000000000000000
630000000000000000000000000000000000000000000000000000000
710000000000000000000000000000000000000000000000000000000
800000000000000000000000000000000000000000000000000000000
900000000000000000000000000000000000000000000000000000000
1000000000000000000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000000000000000000
1250000000000000000000000000000000000000000000000000000000
1400000000000000000000000000000000000000000000000000000000
1600000000000000000000000000000000000000000000000000000000
1800000000000000000000000000000000000000000000000000000000
2000000000000000000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000000000000000000
2500000000000000000000000000000000000000000000000000000000
2800000000000000000000000000000000000000000000000000000000
3200000000000000000000000000000000000000000000000000000000
3600000000000000000000000000000000000000000000000000000000
4000000000000000000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000000000000000000
5000000000000000000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000000000000000000
6300000000000000000000000000000000000000000000000000000000
7100000000000000000000000000000000000000000000000000000000
8000000000000000000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000000000000000000
14000000000000000000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000000000000000000
50000000000000000000000000000000000000000000000000000000000
56000000000000000000000000000000000000000000000000000000000
63000000000000000000000000000000000000000000000000000000000
71000000000000000000000000000000000000000000000000000000000
80000000000000000000000000000000000000000000000000000000000
90000000000000000000000000000000000000000000000000000000000
100000000000000000000000000000000000000000000000000000000000
110000000000000000000000000000000000000000000000000000000000
125000000000000000000000000000000000000000000000000000000000
140000000000000000000000000000000000000000000000000000000000
160000000000000000000000000000000000000000000000000000000000
180000000000000000000000000000000000000000000000000000000000
200000000000000000000000000000000000000000000000000000000000
220000000000000000000000000000000000000000000000000000000000
250000000000000000000000000000000000000000000000000000000000
280000000000000000000000000000000000000000000000000000000000
320000000000000000000000000000000000000000000000000000000000
360000000000000000000000000000000000000000000000000000000000
400000000000000000000000000000000000000000000000000000000000
450000000000000000000000000000000000000000000000000000000000
500000000000000000000000000000000000000000000000000000000000
560000000000000000000000000000000000000000000000000000000000
630000000000000000000000000000000000000000000000000000000000
710000000000000000000000000000000000000000000000000000000000
800000000000000000000000000000000000000000000000000000000000
900000000000000000000000000000000000000000000000000000000000
1000000000000000000000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000000000000000000000
1250000000000000000000000000000000000000000000000000000000000
1400000000000000000000000000000000000000000000000000000000000
1600000000000000000000000000000000000000000000000000000000000
1800000000000000000000000000000000000000000000000000000000000
2000000000000000000000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000000000000000000000
2500000000000000000000000000000000000000000000000000000000000
2800000000000000000000000000000000000000000000000000000000000
3200000000000000000000000000000000000000000000000000000000000
3600000000000000000000000000000000000000000000000000000000000
4000000000000000000000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000000000000000000000
5000000000000000000000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000000000000000000000
6300000000000000000000000000000000000000000000000000000000000
7100000000000000000000000000000000000000000000000000000000000
8000000000000000000000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000000000000000000000
14000000000000000000000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000000000000000000000
50000000000000000000000000000000000000000000000000000000000000
56000000000000000000000000000000000000000000000000000000000000
63000000000000000000000000000000000000000000000000000000000000
71000000000000000000000000000000000000000000000000000000000000
80000000000000000000000000000000000000000000000000000000000000
90000000000000000000000000000000000000000000000000000000000000
100000000000000000000000000000000000000000000000000000000000000
110000000000000000000000000000000000000000000000000000000000000
125000000000000000000000000000000000000000000000000000000000000
140000000000000000000000000000000000000000000000000000000000000
160000000000000000000000000000000000000000000000000000000000000
180000000000000000000000000000000000000000000000000000000000000
200000000000000000000000000000000000000000000000000000000000000
220000000000000000000000000000000000000000000000000000000000000
250000000000000000000000000000000000000000000000000000000000000
280000000000000000000000000000000000000000000000000000000000000
320000000000000000000000000000000000000000000000000000000000000
360000000000000000000000000000000000000000000000000000000000000
400000000000000000000000000000000000000000000000000000000000000
450000000000000000000000000000000000000000000000000000000000000
500000000000000000000000000000000000000000000000000000000000000
560000000000000000000000000000000000000000000000000000000000000
630000000000000000000000000000000000000000000000000000000000000
710000000000000000000000000000000000000000000000000000000000000
800000000000000000000000000000000000000000000000000000000000000
900000000000000000000000000000000000000000000000000000000000000
1000000000000000000000000000000000000000000000000000000000000000
1100000000000000000000000000000000000000000000000000000000000000
1250000000000000000000000000000000000000000000000000000000000000
1400000000000000000000000000000000000000000000000000000000000000
1600000000000000000000000000000000000000000000000000000000000000
1800000000000000000000000000000000000000000000000000000000000000
2000000000000000000000000000000000000000000000000000000000000000
2200000000000000000000000000000000000000000000000000000000000000
2500000000000000000000000000000000000000000000000000000000000000
2800000000000000000000000000000000000000000000000000000000000000
3200000000000000000000000000000000000000000000000000000000000000
3600000000000000000000000000000000000000000000000000000000000000
4000000000000000000000000000000000000000000000000000000000000000
4500000000000000000000000000000000000000000000000000000000000000
5000000000000000000000000000000000000000000000000000000000000000
5600000000000000000000000000000000000000000000000000000000000000
6300000000000000000000000000000000000000000000000000000000000000
7100000000000000000000000000000000000000000000000000000000000000
8000000000000000000000000000000000000000000000000000000000000000
9000000000000000000000000000000000000000000000000000000000000000
10000000000000000000000000000000000000000000000000000000000000000
11000000000000000000000000000000000000000000000000000000000000000
12500000000000000000000000000000000000000000000000000000000000000
14000000000000000000000000000000000000000000000000000000000000000
16000000000000000000000000000000000000000000000000000000000000000
18000000000000000000000000000000000000000000000000000000000000000
20000000000000000000000000000000000000000000000000000000000000000
22000000000000000000000000000000000000000000000000000000000000000
25000000000000000000000000000000000000000000000000000000000000000
28000000000000000000000000000000000000000000000000000000000000000
32000000000000000000000000000000000000000000000000000000000000000
36000000000000000000000000000000000000000000000000000000000000000
40000000000000000000000000000000000000000000000000000000000000000
45000000000000000000000000000000000000000000000000000000000000000
50000000

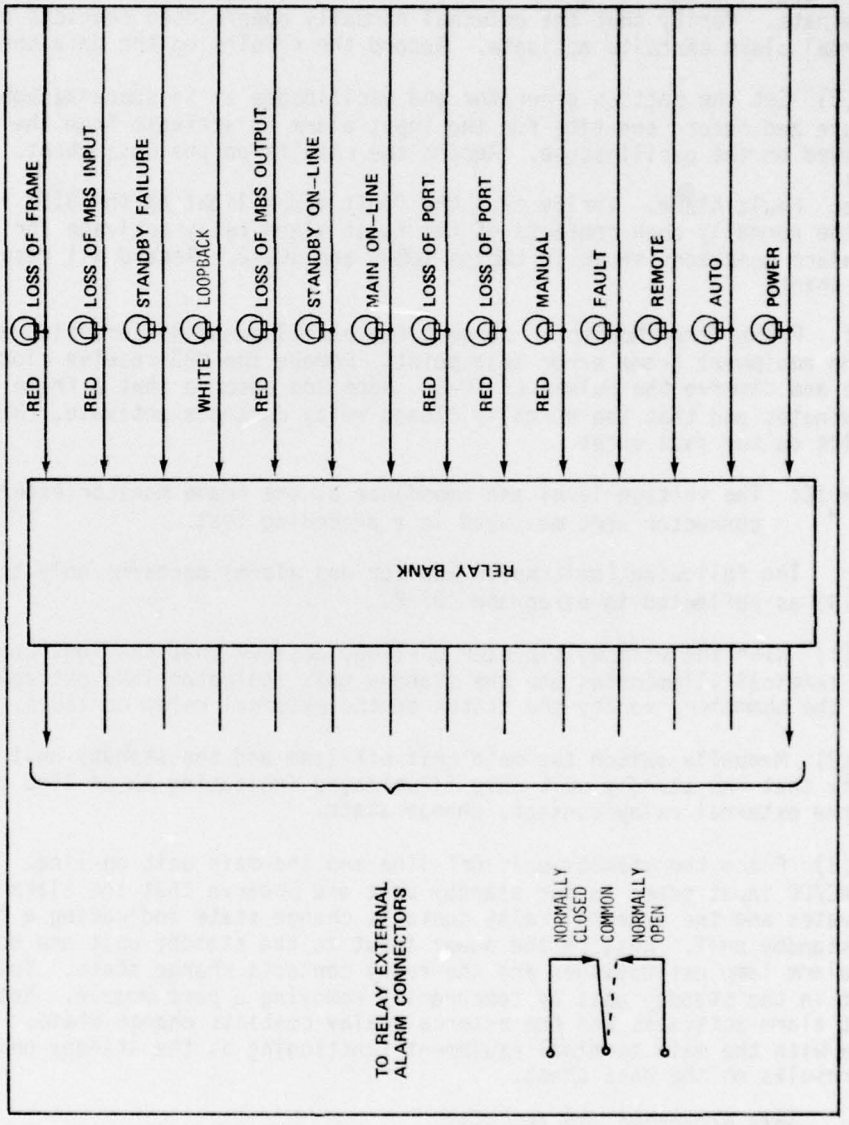


Figure 105-1. Typical alarm indicators (TD-1193).

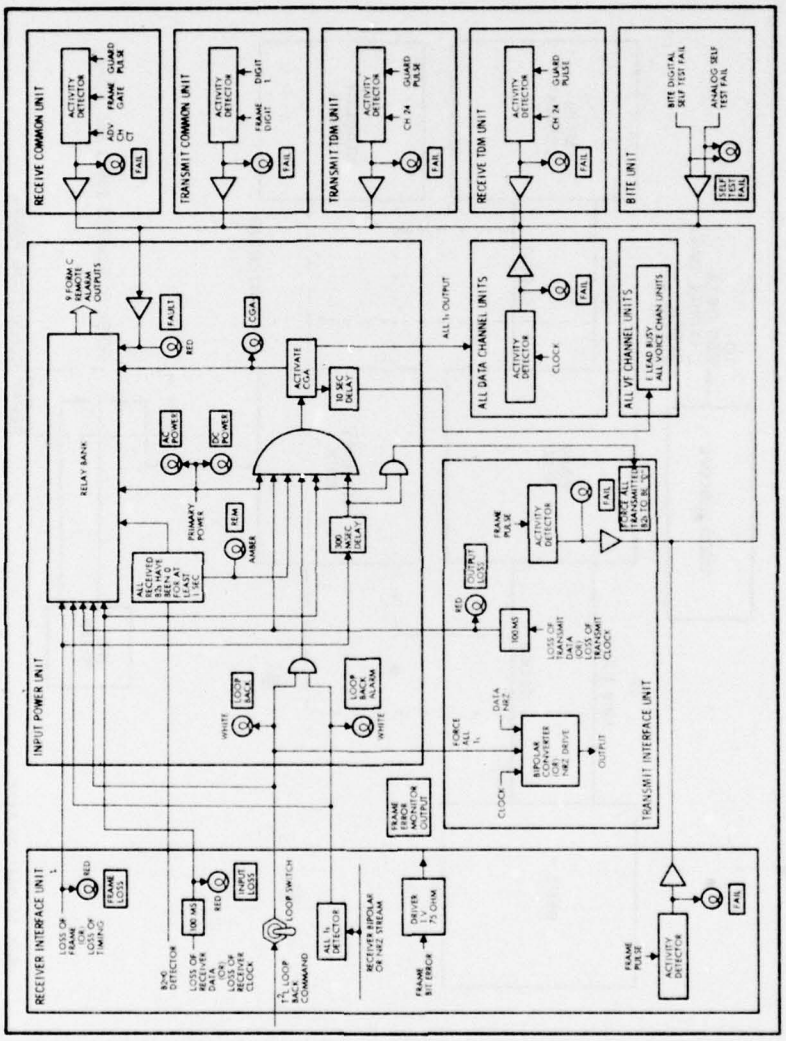


Figure 105-2. Monitor and alarm functions (AN/FCC-98).

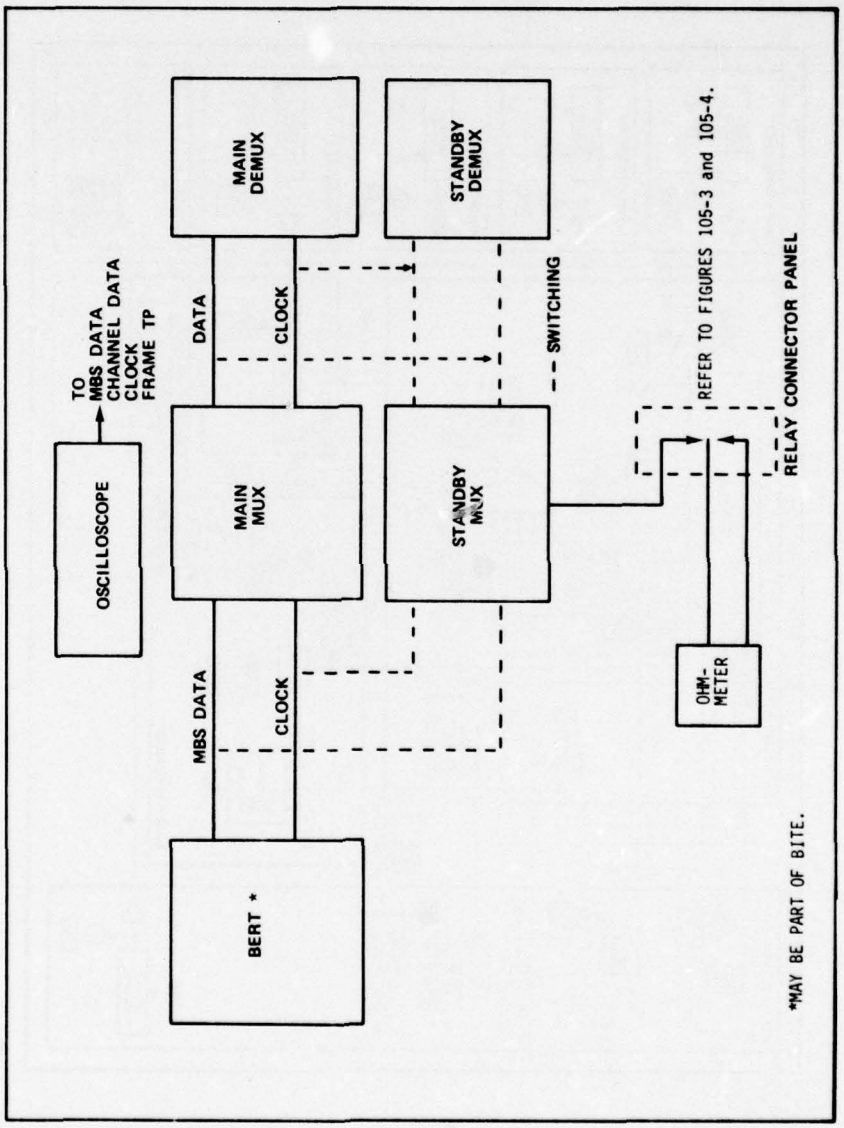


Figure 105-3. TD-1192 (AN/FCC-98) and TD-1193 monitor and alarms test setup.

MULTIPLEX ALARM FUNCTIONS
(CCR 702-1-3)

DATA SHEET

PAGE OF PAGES

DATE (DAY, MO., YEAR)

LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER

EQUIPMENT

C = COMPLIANCE

NC = NON COMPLIANCE

* 100-msec ALARM RECEIVED C ☐ NC ☐

ALARM/FUNCTION	VISUAL INDICATOR		RELAY CONTACTS		C	NC
	YES	NO	ACTIVATED	DEACTIVATED		
INPUT POWER–MAIN						
INPUT POWER–STANDBY						
LOSS OF FRAME LOCAL ☐ REMOTE ☐						
LOSS OF FRAME – MAIN						
LOSS OF FRAME – STANDBY						
LOSS OF MBS OUTPUT – MAIN*						
LOSS OF MBS OUTPUT – STANDBY*						
LOSS OF MBS INPUT – MAIN*						
LOSS OF MBS INPUT – STANDBY* LOCAL ☐ REMOTE ☐						
LOSS OF PORT TO COMMON MODULE						
LOSS OF PORT OUTPUT						
LOOPBACK LOCAL ☐ REMOTE ☐						
CARRIER GROUP ALARM (ALL 1's)						
CGA ALL VF CHANNELS BUSY						
MAIN ON-LINE						
STANDBY ON-LINE						
STANDBY FAILURE						
MANUAL SWITCH – MAIN						
MANUAL SWITCH – STANDBY						
REMOTE SWITCH						
AUTOMATIC SWITCH						
FRAME ERROR						
FAULT ALARM (BITE)						

COMMENTS

USACC FORM 676-R
1 MAY 79

Figure 105-[illegible]. Multiplex alarm functions data sheet.

Table 105-1. TD-1192 (AN/FCC-98) Monitor and Alarms

MONITOR/ALARM FUNCTION	FAILURE INDICATOR
Power supply monitor & alarm	Local Green light off Relay deactivation Carrier group alarm on
Loss of frame alarm	Local Red light on Relay activation Carrier group alarm on Send B2 = 0 Remote Amber light on Relay activation Carrier group alarm on
Loss of output alarm	Local Red light on Relay activation Carrier group alarm on
Loss of input alarm	Local Red light on Relay activation Carrier group alarm on Send B2 = 0 Remote Amber light on Relay activation Carrier group alarm on
Loopback alarm	Local White light on Relay activation Carrier group alarm on Send all 1's Remote White light on Relay activation Carrier group alarm on
Carrier group alarm	Local White light on Relay deactivation All 1's out of data channel Busy all VF channels
Fault alarm	Local Red light on Relay activated
Frame error monitor	Local Pulse provided for each error

Table 105-2. TD-1193 Monitor and Alarm Functions

MONITOR/ALARM FUNCTION	FAILURE FUNCTION	INDICATOR
Primary power loss	Input power-main Input power-standby	Lamp Lamp
Loss of frame	Frame loss-main standby	Red lamp
Loss of MBS output	Loss of MBS-main-standby	Red lamp
Loss of MBS input	Loss of MBS-main-standby	Red lamp
Loss of MBS clock	Clock loss-main-standby	Red lamp
Loss of port to common module	Loss of signal to output connector	Red lamp
Loss of port-to-port output	Loss of signal to common module	Red lamp
Fault	BITE detected failure	Red Lamp
Main on-line	Main active	Lamp
Standby on-line	Standby active	Lamp
Standby failure	--	Lamp
Manual switch	Main and standby	Lamp
Remote switch	Main and standby	Lamp
Automatic switch	Main and standby	Lamp
Loopback	Loopback activated main and standby	White lamp
Frame error*	Frame bit error	Lamp

No external relay contacts.

CHAPTER 106

PROTECTION SWITCHING AND ALARM OPERATION OF THE AN/FRC-162 AND VICOM 4000-2 SYSTEM (DT-303)

106-1. GENERAL.

a. The purpose of this test is to measure the performance and demonstrate the following on the AN/FRC-162 and VICOM 4000-2 system:

(1) VICOM 4000-2 link protection switching.

(2) Microwave radio protection switching.

(3) TSEC/CY-104 and VICOM 4000-2 simulated protection switching.

(4) TSEC/CY-104 group pilot alarm and alarm verification.

(5) Multiplex station alarms.

b. This test may be performed on contractor EF&I systems to verify that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

c. Test procedures for the radio equipment are outlined in DT-231.

106-2. SPECIFICATIONS. The following criteria applies to the AN/FRC-162 and VICOM 4000-2 system.

a. VICOM 4000-2 Link Protection Switching.

(1) Transmit or receive radio fault total equipment traffic outage shall be less than 60 msec without loss of TSEC/CY-104 frame synchronization (local and remote alarm lights of TSEC/CY-104 extinguished). Transmit or receive radio fault total system traffic outage shall be less than 600 msec without the loss of TSEC/CY-104 frame synchronization (local and alarm lights of TSEC/CY-104 remain extinguished).

(2) VICOM 4000-2 multiplexer transmit fault total equipment traffic outage shall be less than 6×10^{-6} errors with a loss of TSEC/CY-104 frame synchronization (local and remote alarms of TSEC/CY-104 illuminate indicating a service alarm). The multiplexer transmit fault total system traffic outage shall be less than 6.5 seconds with loss of TSEC/CY-104 frame synchronization.

(3) VICOM 4000-2 multiplexer receive fault total equipment traffic outage shall be less than 20×10^{3} errors without the loss of TSEC/CY-104 frame synchronization. The multiplexer receive fault total system traffic outage shall be less than 600 msec without a loss of TSEC/CY-104 frame synchronization (local and remote alarm lights remain extinguished).

b. Group Pilot Alarm Extension TSEC/CY-104 Rack Integration. A service alarm in the TSEC/CY-104 that interferes with a group pilot extension unit (configuration 2 or 4) shall produce the following:

(1) The fault alarm lamp on the front panel of the group pilot extension unit shall be illuminated.

(2) The impedance between the following normally open relay contacts shall be less than 1 ohm.

(a) TB1-13 to TB1-14.

(b) TB1-16 to TB1-17.

(c) TB1-19 to TB1-18.

(3) When the service alarm is removed, the impedance between the following points shall be greater than 1 megohm.

(a) TB1-13 to TB1-14.

(b) TB1-16 to TB1-17.

(c) TB1-19 to TB1-18.

(4) The pilot frequency shall be set to 104.08 kHz ±1 Hz.

(5) The groups 1 and 2 nominal pilot level output shall be -54.5 dBm into 135 ohms measured at TB-2 of the group alarm extension unit.

(6) The pilot level drop shall be at least 20 dB from the nominal measured at TB-2 of the group alarm extension unit.

(7) The FDM through-group loss (group distribution frame (GDF)-to-GDF) shall be less than 0.6 dB.

106-3. TEST EQUIPMENT REQUIRED.

a. VICOM 4000-2 Link Protection Switching.

(1) Waveguide attenuator (0 to 50 dB variable).

(2) Power meter.

(3) RF voltmeter.

(4) Oscillator.

(5) Frequency counter.

(6) AC voltmeter.

b. TSEC/CY-104 Alarm Operation and Verification.

(1) Oscilloscope.

(2) Patch cable (bantam).

c. Group Pilot Alarm Extension Units. Ohmmeter.

106-4. TEST PROCEDURES.

a. VICOM 4000-2 Link Protection Switching Operation.

(1) Preliminary setup.

(a) Connect the TSEC/CY-104, VICOM 4000-2 radio racks, and test equipment as shown in figure 106-1 and allow approximately 30 minutes for warmup and stabilization. A typical alarm flow diagram for the multiplex is shown in figure 106-2.

(b) Monitor the AGC volts (using a DC multimeter) at TP-3 and TP-4 of the IF amplifier/demodulator assembly of radio receivers 1 and 2 for an AGC DC level corresponding to -25 dBm RSL according to the receiver calibration chart. The waveguide attenuators AT-1 and AT-2 are adjusted to produce the aforementioned DC voltage.

(c) Place the VICOM 4000-2 multiplexer protection switch unit transmit switch common and receive switch common front panel transfer to standard and reset to normal switches in the down position. Place the automatic transfer disable switches in the down position. Momentarily place the reset to normal switches of the 4033 transmit switch common and the 4034 receive switch common modules in the down position. This places the VICOM 4000-2 multiplexer occupying the upper portion above the protection switch in operation.

(d) Connect the oscillator to the baseband in jack of radio 1. Adjust the signal level to 0.35 mV RMS/75 ohms at 1.0 MHz using the AC voltmeter and the frequency counter.

(e) Connect the counter to the baseband out jack of radio 2.

(2) Microwave radio protection switching.

(a) Set the time base/multiplier control of the counter to 1 second. Take three successive 1-second readings of the 1-MHz signal with the counter. Compute the average of the three readings. Record the result as reading A on figure 106-3 (USACC Form 677-R).

(b) Set the time base/multiplier control of the counter to 10 seconds. Press the counter reset button to initiate a 10-second count. Record the readout as reading B.

(c) Initiate another 10-second frequency count. After approximately 5 seconds, remove the 70-MHz output cable between the mixer and equalizer of radio 2. This will cause a switchover to the standby unit. Record the readout as reading C.

(d) Calculate the traffic outage due to a receiver fault from the values recorded in subparagraphs (a), (b), and (c), above, as follows:

$$\text{Outage (in seconds)} = \frac{B - C}{A}$$

(e) Reconnect the 70-MHz cable between the mixer and equalizer of radio 2. Reset the radio protection switch for the normal unit on-line.

(f) Repeat subparagraph (1), above, for an updated reading A.

(g) Repeat subparagraph (2), above, for an updated reading B.

(h) Initiate another 10-second frequency count. After approximately 5 seconds, remove the cable from the power detector to the directional coupler of the radio 1 on-line transmitter. This will cause a transmit radio switchover to the standby unit. Record the readout as reading C.

(i) Calculate the traffic outage due to a radio transmitter fault from the values recorded in subparagraphs (f), (g), and (h), above, as follows:

$$\text{Outage (in seconds)} = \frac{B - C}{A}$$

(j) Replace the radio transmitter cable removed in subparagraph (h), above. Restore the radio transmitter normal unit to on-line.

(3) VICOM 4000-2 multiplexer protection switching.

(a) Connect the VICOM 4000-2 test word generator-detector module transmit and receive points to the TDM rack AI J10-T1 channel 2 transmit and AL J2-T1 channel 2 receive connectors, respectively.

(b) Remove the oscillator and counter connected to the radio.

(c) Connect the VICOM 4000-2 normal multiplexers to the radio by connecting (1) a video patch cable between J8-N, the multiplexer to transmitter jack of the protection switch 4031 jack block assembly, and the radio transmit baseband in jack and (2) a video patch cable between the J10-N from receiver jack of the protection switch 4031 jack block assembly and the radio receive baseband out jack. This hookup is made for both directions of transmission as shown in figure 106-1.

(d) Connect the TSEC/CY-104 bipolar out transmit A5 J1 equipment jack and the bipolar in receive A5 J2 equipment jack to the TDM rack A1 J0 T1 channel 1 transmit and A1 J1 T1 channel 1 receive connectors, respectively.

(e) Connect the counter to the error output of the 4027-01 test word generator-detector of the receive TDM rack. Set the counter for a 10-second count.

(f) Initiate a 10-second error count. After 1 to 2 seconds, insert a video plug into the VICOM 4000-2 multiplexer front panel jack (the J7-N from multiplexer breaking jack of the protection switch jack block assembly 4031). This will simulate an on-line transmit multiplexer fault by breaking the connection (via the protection switch) from the on-line unit to the radio transmitter.

(g) Record the 10-second counter error readout for the TDM transmit fault. During the 10-second count, monitor the local and remote alarm front panel lights of the TSEC/CY-104 for a service alarm indication. Note whether or not they illuminate during the test period. Wait until the 10-second period concludes and then push the frame reset switch on the front panel of the model 7070 power and alarm unit, a part of TSEC/CY-104. This pushbutton extinguishes the framelight when the terminal reframes. Note whether or not the terminal reframes.

(h) Remove the video plug from the VICOM 4000-2 patch panel 1. Restore the normal transmit unit to the on-line position by momentarily pressing the transfer to standby/reset to normal switch of the protection switch subunit 4033 transmit switch common down.

(i) Initiate another 10-second error count. After approximately 5 seconds, remove the model 4024 receive time base unit of the on-line normal VICOM 4000-2 multiplexer 2. During the 10-second count, monitor the local and remote alarm lights of the TSEC/CY-104 and note whether they illuminate during the test period. Record the 10-second error count for TDM receive faults.

(4) TSEC/CY-104 and VICOM 4000-2 radio simulated system protection switching.

(a) Disconnect the VICOM 4000-2 test word generator-detector connections of subparagraphs (3) (a) and (c), above.

(b) Connect the oscillator to the TSEC/CY-104 rack transmit channel 1 jack, A3 J1 equipment jack. Adjust the signal level to -16 dBm (125 mV RMS/600 ohms) at 1020 Hz using the AC voltmeter and the frequency counter.

(c) Connect the counter to the TSEC/CY-104 rack receive channel 1 jack, A4 J1 equipment jack. The test setup should now be according to figure 106-1.

(d) At a convenient start time, press the frame reset switch on the front panel of the model 7070 power and alarm unit, a module of the HY-12 portion of TSEC/CY-104. This pushbutton extinguishes the frame light when the terminal reframes. Note whether or not the terminal reframes.

(e) Set the time base/multiplier control of the counter to 1 second. Take three successive 1-second readings of the 1020-Hz signal with the counter. Compute the average of the three readings. Record the average as reading A.

(f) Repeat subparagraphs a(2) (b) through (d), above. These procedures demonstrate the effects of transmit and receive radio faults on system traffic outage.

(g) During the 10-second count, monitor the local and remote alarm front panel lights of the TSEC/CY-104 for a service alarm indication. Note whether or not they illuminate during the test period. If they illuminate, wait until the testing concludes and then push the frame reset switch on the front panel of the model 7070 power and alarm unit, a part of TSEC/CY-104. This pushbutton extinguishes the frame light when the terminal reframes. Note whether or not the terminal reframes.

(h) Repeat subparagraph (4)(e), above, for an updated reading of A.

(i) Set the time base/multiplier control of the counter for a 10-second count. Press the counter reset button to initiate a 10-second count. Record the counter readout as reading B.

(j) Initiate another 10-second frequency count. After 1 to 2 seconds, insert a video plug into the VICOM 4000-2 multiplexer front panel jack, the J7-N from multiplexer breaking jack of the protection switch jack block assembly 4031. This will simulate an on-line transmit multiplexer fault by breaking the connection (via the protection switch) from the on-line unit to the radio transmitter. Record the 10-second counter readout as reading C.

(k) Repeat subparagraph (4)(g), above.

(l) Calculate the system traffic outage due to a VICOM 4000-2 multiplexer transmitter fault from the values recorded in subparagraphs (4) (h) through (j), above, as follows:

$$\text{Outage (in seconds)} = \frac{B - C}{A}$$

(m) Remove the video plug from the VICOM 4000-2 patch panel 1. Restore the normal transmit unit to the on-line position by momentarily pressing the transfer to standby/reset to normal switch of the protection switch subunit 4033 transmit switch common down.

(n) Repeat subparagraph (4)(e), above, for an updated reading of A.

(o) Repeat subparagraph (4)(i), above, for an updated reading of B.

(p) Initiate another 10-second frequency count. After approximately 5 seconds, remove the model 4024 receive time base unit of the on-line normal VICOM 4000-2 multiplexer 2. Record the 10-second count as reading C.

(q) Calculate the system traffic outage due to VICOM 4000-2 multiplexer receive faults from the values recorded in subparagraphs (4) (n) through (p), above, as follows:

$$\text{Outage (in seconds)} = \frac{B - C}{A}$$

(r) Repeat the above procedures for all multiplexers.

b. TSEC/CY-104 Alarm Operation and Verification.

(1) Connect the TSEC/CY-104 equipment in a back-to-back configuration; that is, connect a patch cable between the bipolar output and bipolar input jacks of the TSEC/CY-104 interface unit patch field as shown in figure 106-4.

(2) Place the NRZ/bipolar switch in the bipolar position.

(3) Check that the manual/automatic switch on the HN-74 alarm unit is in the automatic position.

(4) Unplug the HN-74 terminal matching unit. This should cause a local alarm in the TSEC/HY-12 (indicated by the TSEC/HY-12 local and frame lamps lighting).

(5) Push the reset button on the HN-74 power supply. With an oscilloscope, observe the preparation (PREP) and end around preparation (EAP) pulses at the test points on the HN-74 alarm unit.

(6) Push the reset button again and, observing the preparation pulses on the oscilloscope, check that the green restart alarm light on the HN-74 power supply comes on after 32 preparation pulses (approximately 32 seconds).

(7) Plug in the HN-74 terminal matching unit. Push the TSEC/KG-34 transmitter preparation button. This should cause system synchronization. Check that the restart alarm light extinguishes. The TSEC/HY-12 local alarm light should be off. Push the TSEC/HY-12 frame button to extinguish the frame light.

(8) When all alarm indicators are off and the white TSEC/KG-34 transmitter and receiver operation lights are on, the system should be operating properly.

(9) With the manual/automatic switches of both terminals in automatic, push the terminal A TSEC/KG-34 receiver preparation button to see that the TSEC/KG-34's of both systems reframe. The TSEC/HY-12 local alarm may light momentarily and the frame light should come on.

(10) At terminal A, remove the terminal fuse, remove the transmit common unit, and then replace the terminal fuse. Terminal B should go into local alarm and terminal A should indicate a remote alarm. Push the reset button on terminal B of the HN-74 power supply. Terminal A will clock 32 times and then the restart alarm light on terminal B of the HN-74 should come on. At terminal A, remove the terminal fuse, replace the transmit common unit, and then replace the terminal fuse. The restart alarm light at terminal B should extinguish as

well as all other alarms. The TSEC/HY-12 frame lights will remain on until the frame buttons are pushed.

(11) Repeat subparagraphs (8) and (9), above, in the opposite direction for end-to-end operation.

c. Group Pilot Alarm Extension Units. This test is applicable only to those units equipped with a pilot relay card.

(1) Create a service alarm in the TSEC/CY-104 by inserting a plug into the bipolar-in-receive line jack of the bipolar in/out patch panel, A5.

(2) Observe that the group pilot alarm extension unit fault alarm lamp is illuminated.

(3) Using an ohmmeter, measure the impedance between the following relay contacts of TB-1 of the group alarm extension unit

(a) TB1-13 to TB1-14.

(b) TB1-16 to TB1-17.

(c) TB1-19 to TB1-18.

NOTE: The measured impedance in each case shall be less than 1.0 ohm.

(4) Remove the plug inserted in subparagraph (1), above.

(5) Repeat the impedance measurement made in subparagraph (3), above.

NOTE: The measured impedance in each case shall be greater than 1 megohm.

d. Monitor and Alarm (D2 and D3 VICOM Terminal Equipment). The following monitor/alarm functions may be verified using the procedures outlined in DT-302.

(1) Local - red.

(a) Receiver cannot reframe, 0.3 second.

(b) Blown fuse.

(2) Carrier group alarm - white.

(3) PCM alarm code, remote - amber.

(4) Local loop - green.

(5) Service alarm.

106-5. DATA RECORDING AND ANALYSIS.

a. Record all data on figure 106-3 (USACC Form 677-R) and verify that the test results meet or exceed the requirements of paragraphs 106-2. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system/equipment fails to meet specified performance, notify the responsible activity of the required corrective actions.

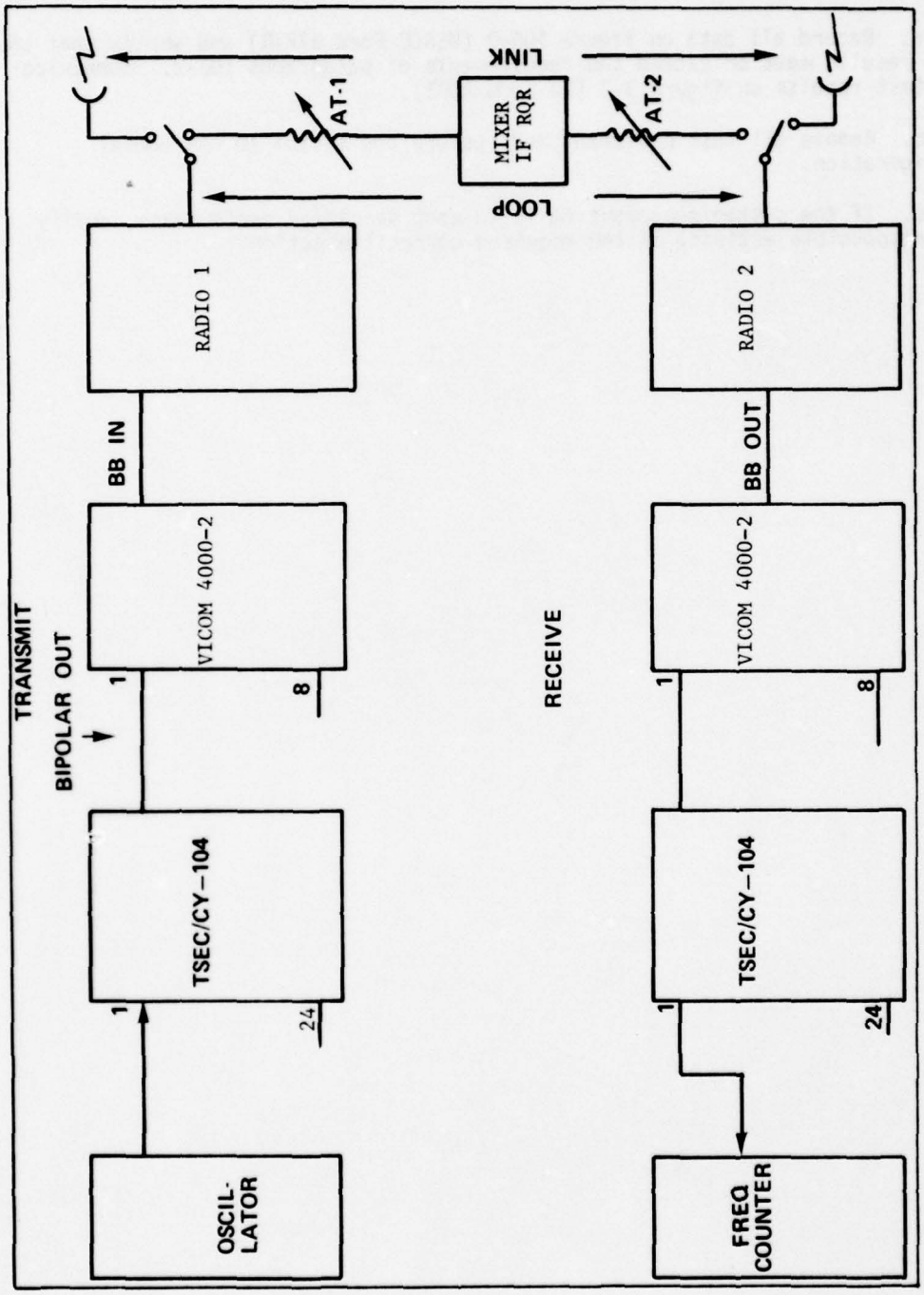


Figure 106-1. VICOM 4000-2 link protection test setup.

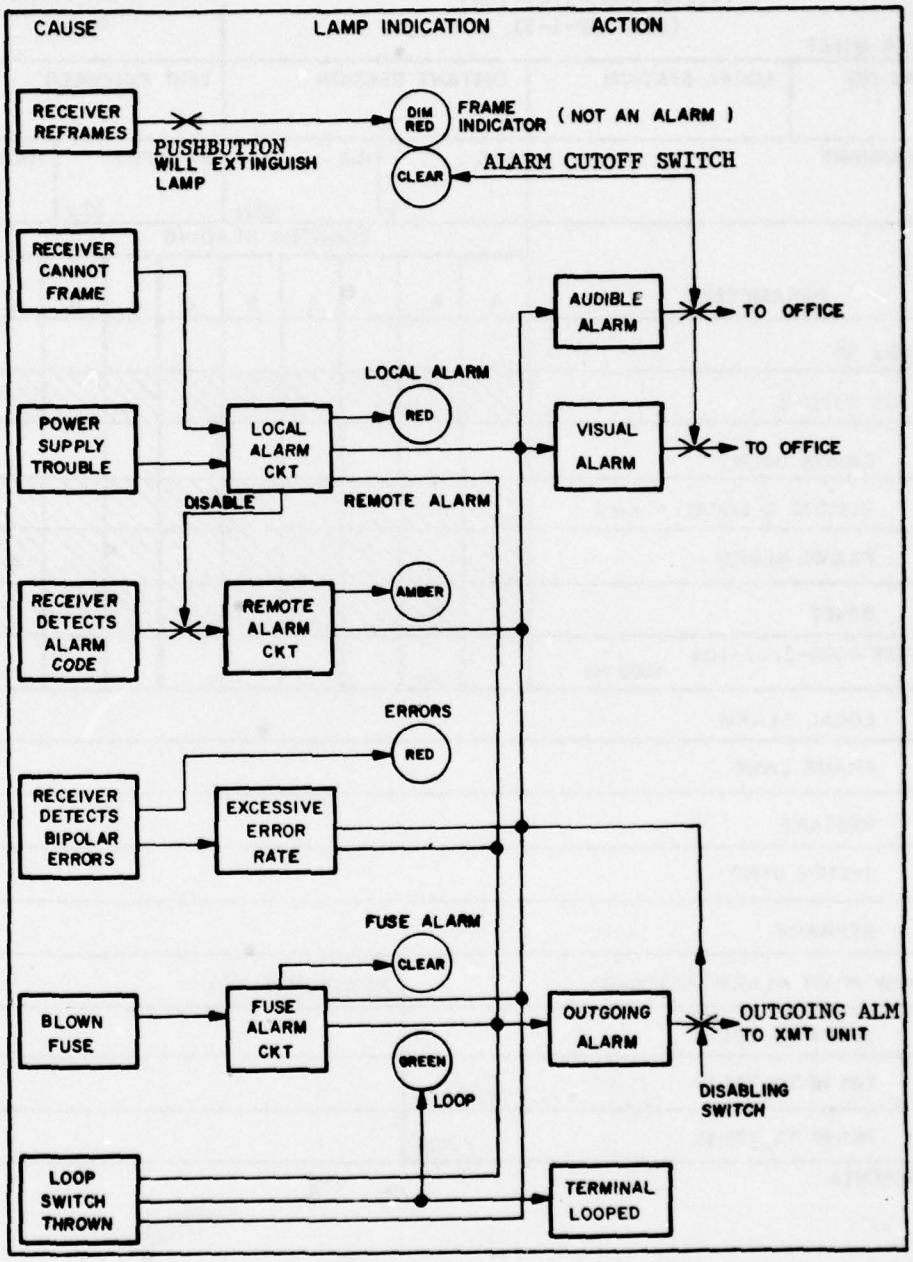


Figure 106-2. Typical alarm flow diagram for multiplex.

MONITOR AND ALARM OPERATION (VICOM 4000-2/CY-104) (CCR 702-1-3) DATA SHEET												PAGE OF PAGES / DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION										TEST ENGINEER
EQUIPMENT		AGC V			RSL dBm			BB INPUT MHz			RADIO A – B B – A	
		COUNTER READING										
PARAMETER		A	B	C	A	B	C	A	B	C	C	NC
1-MHz BB												
VICOM 4000-2												
ERROR COUNT												
REMOTE & LOCAL ALARM												
FRAME ALARM												
RESET												
VICOM 4000-2/CY-104 1000 Hz												
LOCAL ALARM												
FRAME LAMP												
RESTART												
SYSTEM SYNC												
REFRAME												
GROUP PILOT ALARM INDICATOR		RESISTANCE (Ω)										
TB1-13 TO TB1-14												
TB1-16 TO TB1-17												
TB1-19 TO TB1-18												
COMMENTS												

NOTE: To compute average of A, B, and C readings, use the following formula:

$$\text{Outage (in seconds)} = \frac{B-C}{A}.$$

USACC FORM 677-R
1 MAY 79

Figure 106-3. Monitor and alarm operation (VICOM 4000-2/CY-104) data sheet.

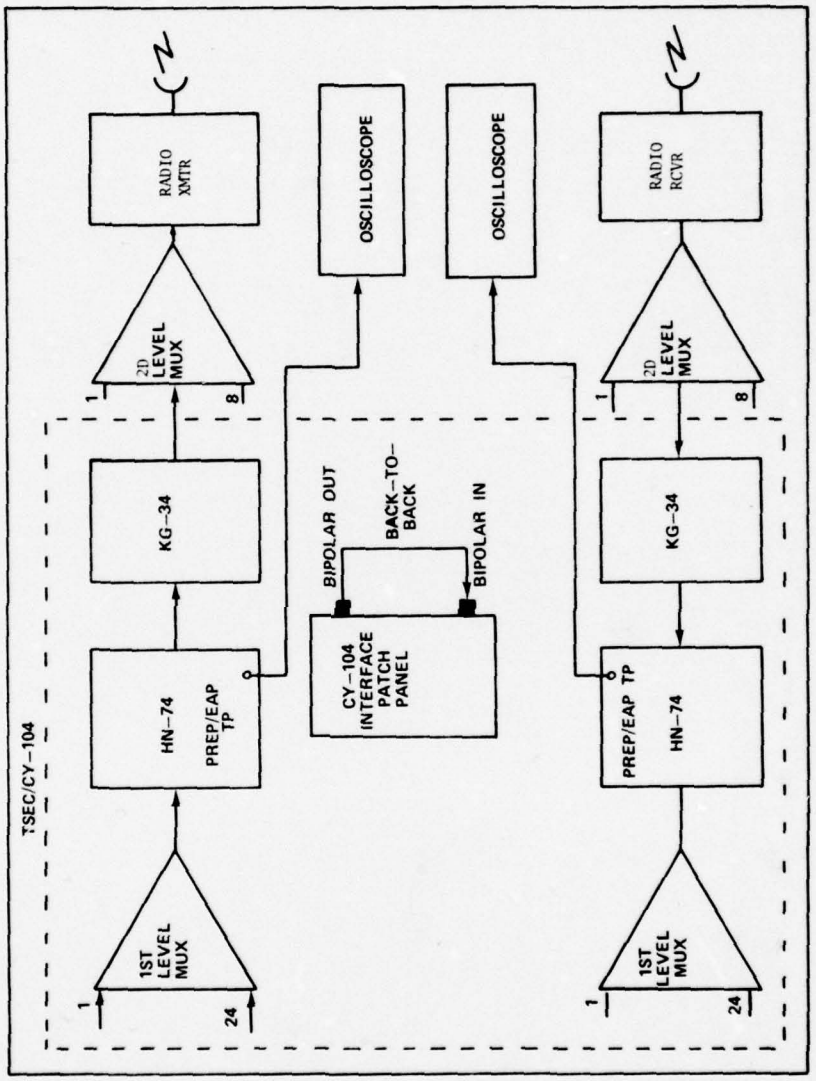


Figure 106-4. CY-104 alarm operation test setup.

CHAPTER 107

BUILT-IN TEST EQUIPMENT (DT-304)

107-1. GENERAL.

a. The purpose of this test is to verify and record the performance capabilities of the BITE.

b. The AN/FRC-162 and VICOM 4000-2 system has built-in facilities for determining circuit and system status. A summary of the BITE capabilities follows:

(1) Test word generator for transmitting a bipolar 1.544-mb/s data stream.

(2) Provisions for measuring:

(a) Transmit and receive voice frequency channel levels.

(b) Circuit balance.

(c) Crosstalk.

(d) Distortion.

(e) Transmit and receive common gain.

(3) Test oscillator 1020-Hz input filter.

c. This test may be performed on contractor EF&I systems to ensure that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

107-2. SPECIFICATIONS.

a. The TD-1192 (AN/FCC-98) multiplex terminal shall have integral test facilities for measuring, testing, and monitoring signals in and out of the units and for operation of the internal circuits. The integral test facilities shall include a test oscillator (1020±5 Hz), a method to measure DC power supply voltages, and a go-no go fault locator circuitry to isolate failures to a particular plug-in module or card. Go-no go fault locator circuitry is not required for the voice frequency channel card. The test oscillator shall be used to aline voice frequency channels to the output level from +3 to -7 dBm for the 0-dBm0 output option and from +10 to 0 dBm for the +7 dBm0 output option. The test oscillator output shall be 0 dBm ±0.1 dB and -16 dBm ±0.1 dB when terminated in 600 ohms. Metering facilities or other indicating devices in conjunction with switches shall be provided to ensure proper operation of the multiplex terminal and to monitor the DC voltages, go-no go fault

location function, and other critical internal and external signals. The internal test facilities shall be such that they may be operated without interrupting traffic or interfering with normal system operation. Circuits for monitoring shall be placed on separate removable connectors on plug-in module(s) and card(s) wherever practical. Connectors used to interconnect the module(s) or card(s) to the multiplex terminal shall be male. Pin-pick type connectors may be used for front panel test points. (CCC-74047)

b. The following criteria applies to the TD-1193. (CCC-74048)

(1) The TDM shall have integral test facilities for the measuring, testing, and monitoring of signals in and out of the TDM and of the operation of the internal circuits. The integral test facilities shall include a method to measure DC power supply voltages and a go-no go fault locator circuitry to isolate failures to a particular plug-in module or card. Metering facilities or other indicating devices in conjunction with switches shall be provided to ensure proper operation of the TDM and to monitor the DC voltages, go-no go fault function, and other critical internal and external signals. The internal test facilities shall be such that they may be operated without interrupting traffic or interfering with normal system operation. Circuits providing the monitoring functions shall be on separate removable plug-in module(s) or card(s) wherever practical. Indicators may be used on the front of each plug-in module or card for go-no go fault location. All operations of the TDM except those directly related to integral test facility plug-in module and the isolation of failure shall not be affected by the removal of the integral test facility plug-in module from the TDM.

(2) Provisions shall be included in the TDM for transmitting pseudorandom digital data over a single port of the TDM at a rate of 1.544 mb/s ±200 b/s for the purpose of making BER measurements at the receive port. Errors in the transmitted bit stream shall be detected at the receive end and the error pulses shall be routed through a standard BNC connector. The output impedance shall be 78 ohms ±10 percent (unbalanced). The BER signal shall be 50-percent unipolar, 1 volt ±10 percent square pulses. The pseudorandom shift register shall have a mimimum length of 20 bits and shall have a self-check mode by generating a fixed amount of errors at the transmit end and detecting the amount at the receive end. The pseudorandom generator-detector shall be an integral part of the TDM and provisions shall be included to insert, by switch or by cables supplied with the TDM, the pseudorandom digital data into the selected port. Removal of the pseudorandum generator-detector from the TDM shall not affect normal operation of the TDM.

c. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

107-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Digital voltmeter.

c. Voice frequency oscillator.

d. dB meter.

e. Oscilloscope.

f. Frequency counter.

g. Connectors, cables, etc., as required.

107-4. TEST PROCEDURES.

a. TD-1192 (AN/FCC-98).

(1) *DC voltage.* (Refer to figure 107-1.)

(a) Set the DC power supply switch (S201) to position 1. Set the BITE function switch (S202) to DC volts.

(b) Read and record the voltage as observed on the BITE internal meter. The voltage should be -42 VDC ±10 percent. Record the results on figure 107-2 (USACC Form 678-R).

(c) Repeat subparagraphs (a) and (b), above, for positions 2 through 10 of the BITE DC select switch. Record the results on figure 107-2 (USACC Form 678-R).

(d) To confirm the accuracy of the internal BITE meter, connect an external digital voltmeter at the output power supply DC test points and repeat subparagraphs (a) through (c), above.

(2) *Voice frequency oscillator.* (Refer to figure 107-3a.)

(a) Connect a frequency counter to the BITE voice frequency oscillator jack (J202). Measure and record the frequency on figure 107-2 (USACC Form 678-R).

(b) Connect a dB meter (C-message) to the oscillator output jack (J202). Set the BITE function switch (S202) to transmit. Set the level select switch (S205) to 0 dBm. Terminate the dB meter into 600 ohms. Read the oscillator output level and record the level on figure 107-2 (USACC Form 678-R). Change the BITE level select switch (S205) to -16 dBm. Record the level on figure 107-2 (USACC Form 678-R).

(3) *Voice frequency meter accuracy.* (Refer to figure 107-3a.)

(a) Set the BITE meter attenuation switch (S203) to 0 dBm.

(b) Set the BITE function switch to the receive position and connect the test oscillator to the voice frequency meter input jack.

(c) Adjust the external oscillator for 1020 Hz at 0-dBm output. Read and record the BITE voice frequency meter reading.

(d) Adjust the external oscillator through the frequency range shown on figure 16-4 (DD Form 2095) and record the BITE voice frequency meter reading at each frequency. Plot the meter inaccuracy on figure 3-4 (DD Form 2094).

NOTE: On figure 16-4 (DD Form 2095), change SG to read port and GP to read digroup.

(e) Change the BITE voice frequency meter attenuation switch to -10 dBm and repeat subparagraphs (a) through (d), above.

NOTE: Due to the multiple functions of the BITE voice frequency meter, there is a good possibility that it will not be linear over its measurement range.

(4) *E&M channel.*

(a) Set the BITE function switch to loop test.

(b) Connect the BITE signal output to the voice frequency channel signal input with an appropriate patch cord

(c) Turn the BITE on-hook/off-hook switch (S204) to the off-hook position. Depress the carrier group alarm defeat switch on the power and alarm panel and observe that the off-hook lamp illuminates.

(d) Turn the on-hook/off-hook BITE switch to on-hook. The off-hook lamp should extinguish.

(5) *Data function.* (Refer to figure 107-1.)

(a) Set the BITE digital function switch to measure data and select a synchronous data channel on the terminal unit. Set the BITE data rate and balanced/unbalanced switches to correspond to the channel under test.

(b) Set the BITE function switch to loop test.

(c) Connect the synchronous out, data out, and clock out of the channel under test to clock in (transmit), data in, and clock in (receive), respectively.

(d) Connect the data in and clock in of the channel under test to data out and clock out of the BITE.

(e) Momentarily press the transmit error inject switch on the BITE and verify that the error lamp flashes. Disconnect the data cable and verify that the error rate lamp activates. Record the results on figure 107-2 (USACC Form 678-R).

b. TD-1193. (Refer to figure 107-3b.)

(1) *DC voltage measurements.*

(a) Turn the BITE function switch on.

(b) With suitable patch cords, connect the BITE DC positive and negative pin input jacks to the power module regulated output voltage jacks.

(c) Measure and record the results for the input and output voltages on figure 107-2 (USACC Form 678-R).

(2) *Pseudorandom generator-detector.* (Refer to figure 107-3b.)

(a) With suitable patch cords, connect the port under test to the BITE input by connecting the transmit bipolar or NRZ (as applicable) to the output jack of the BITE. Connect the receive port output data to the in jack of the BITE. Connect the BITE clock-in and out jacks to the port under test.

(b) Set the BITE format switch to correspond to the channel/port input/output data format (NRZ or bipolar).

(c) Connect an external bit error detector to the BNC error pulse signal test point on the back plane of the equipment.

(d) Momentarily place the normal/self-test switch to self-test and observe that the error lamp illuminates. Verify that the external error detector counts the errors being injected.

(e) Record the results on figure 107-2 (USACC Form 678-R).

NOTE: The impedance and voltage levels of the external error test jack should be measured as outlined in DT-293.

c. AN/FRC-162 and VICOM 4000-2 System. (Refer to figure 79-2.)

(1) Connect a test oscillator to the oscillator in jack (J202) of the 7060 test panel. Adjust the oscillator for 1020 Hz at 0 dBm (600 ohms (balanced)).

(2) Connect the voltmeter to the jack of the test panel. Set the channel type switch of the test panel to 600 ohms (four wire) and the bridging/termination switch to 600 ohms termination. Set the function switch to the transmit channel level. Place pads A and B of the test panel in the out position.

(3) Record the oscillator output level and frequency from the voltmeter and frequency counter on figure 107-2 (USACC Form 678-R). Repeat subparagraphs (1) and (2) with pad A in, pad B out, and both pads in. Record the results.

(4) Patch the transmit and receive lineup jacks of the test panel to the channel lineup jacks of the unit under test.

(5) Set pads A and B of the test panel to correspond to the channel input/output level and turn the channel busy switch to busy. Loop the channel or terminal. With the voltmeter, measure the receive test tone level and record the results.

107-5. DATA RECORDING AND ANALYSIS.

a. Review the data for compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the unit fails to meet the specified performance requirements, notify the responsible activity of required corrective actions.

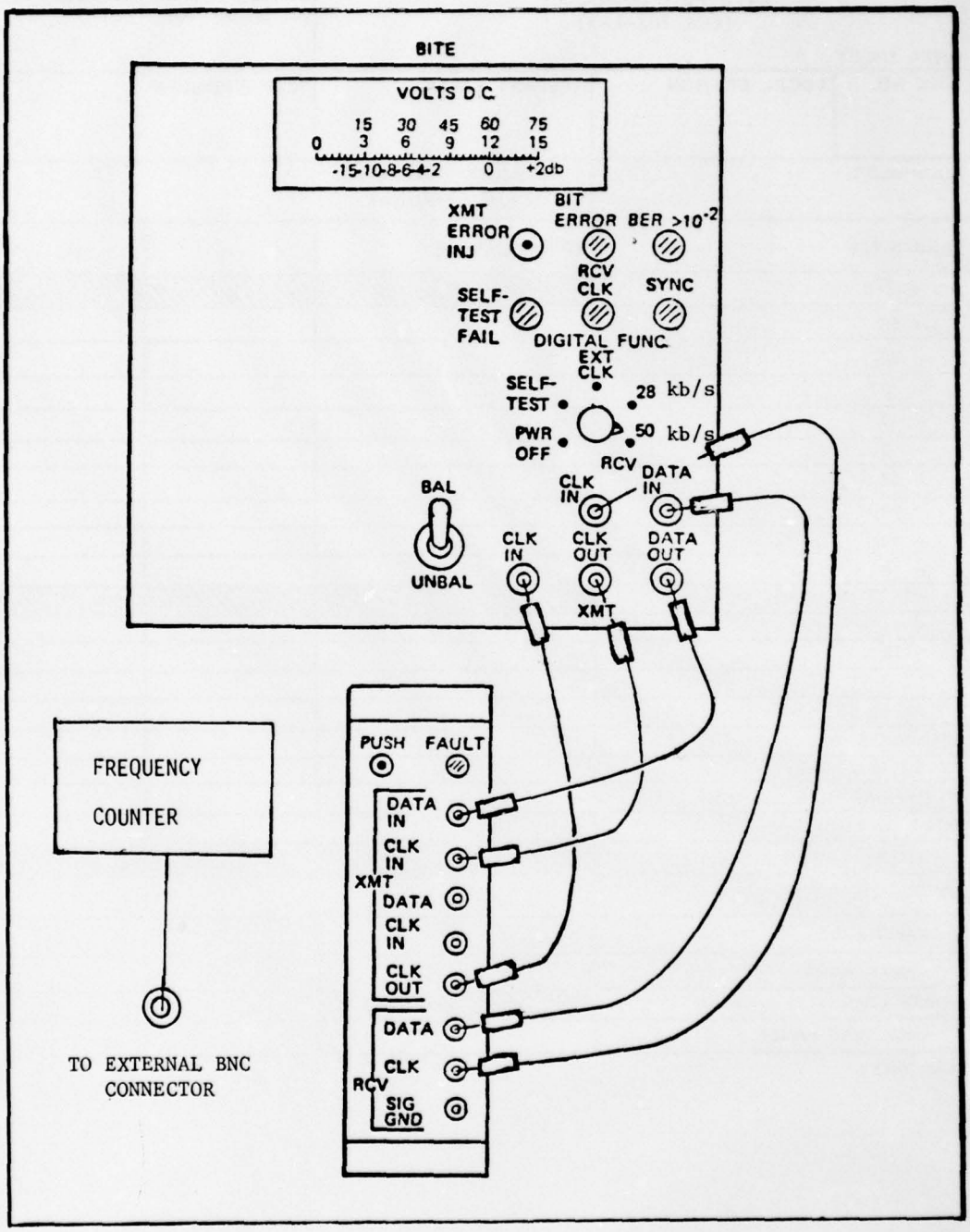


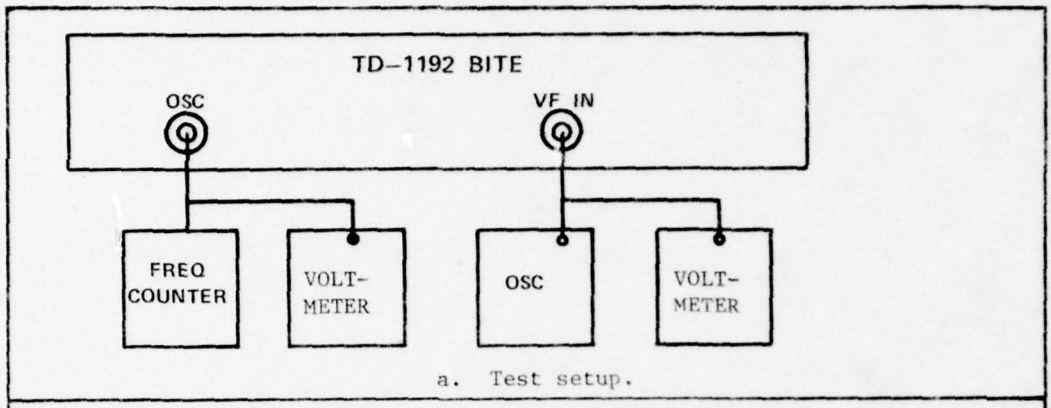
Figure 107-1. TD-1192 (BITE) data function test setup.

CCP 702-11

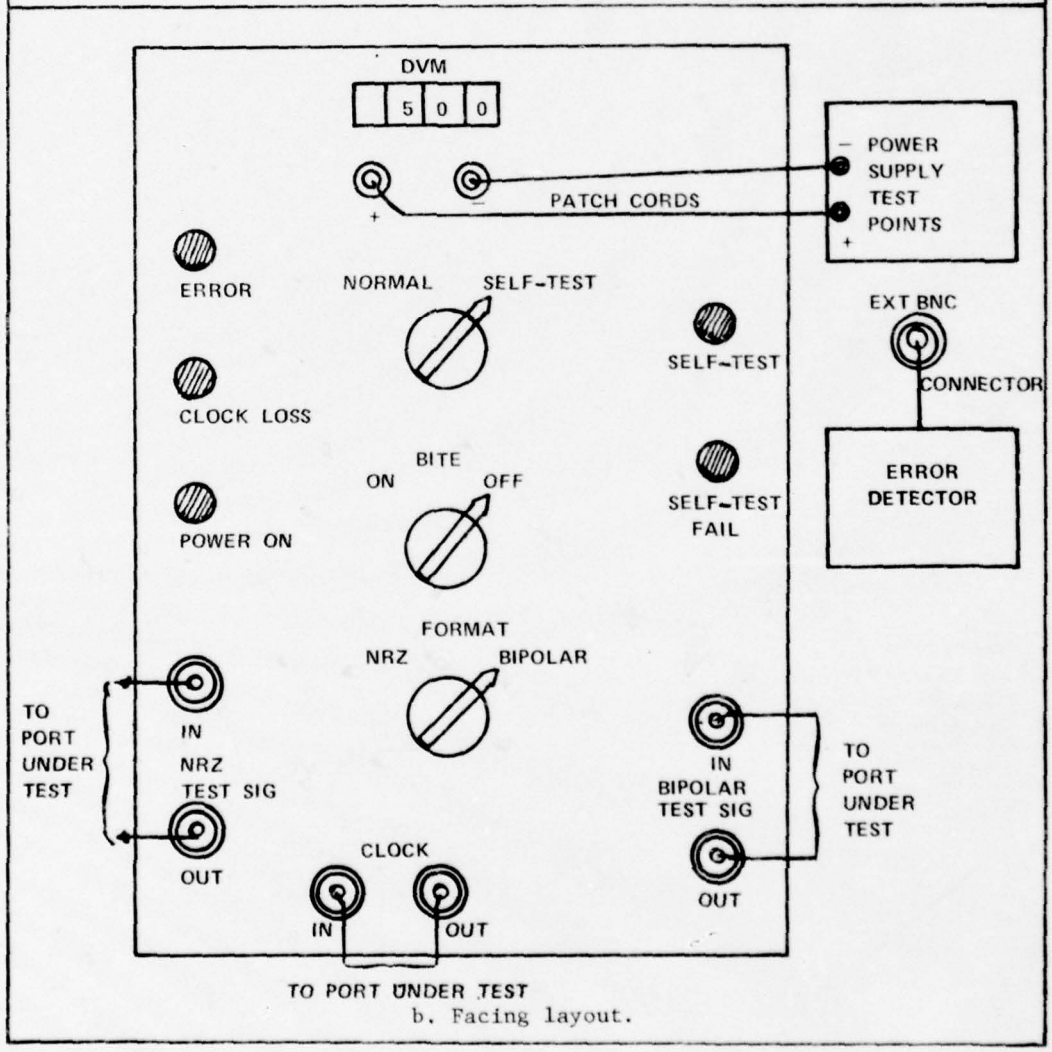
BITE PERFORMANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)	
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER	
EQUIPMENT		PRIMARY TERMINAL ☐ BACKUP TERMINAL ☐		
PARAMETER		SPECIFICATION	C	NC
DC POWER (V)				
− 42				
− 38				
− 12				
− 7				
− 5				
+ 12				
− 48				
− 40				
− 15				
VF FUNCTION (dBm)				
+ 7				
− 16				
0				
FREQUENCY (Hz)				
METER ACCURACY				
ON/OFF-HOOK INDICATOR				
BER FUNCTION				
EXTERNAL ERROR CONNECTOR				
ERRORS DETECTED				
IMPEDANCE				
LEVEL (VPP)				
ERROR LAMP ILLUMINATES				
7060 TEST PANEL				
COMMENTS				
NOTE: C = COMPLIANCE; NC = NONCOMPLIANCE.				

USACC FORM 678-R
1 MAY 79

Figure 107-2. BITE performance data sheet.



a. Test setup.



b. Facing layout.

Figure 107-3. TD-1193 (BITE) test setup and facing layout.

CHAPTER 108

DATA CHANNEL CHARACTERISTICS (50 kb/s) (DT-305)

108-1. GENERAL.

a. The purpose of this test is to determine the performance characteristics of the 50-kb/s data channel of the TD-1192 (AN/FCC-98) multiplex terminal. This includes:

(1) Asynchronous 50-kb/s tandem performance.

(2) Unbalanced performance.

(3) Output data distortion.

b. This test may be performed on contractor EF&I systems to verify that they meet specified performance parameters. It may also be used by installer or quality assurance personnel during onsite test activities as directed. It is, however, more applicable during design verification than routine onsite testing.

c. This test is not applicable to the TD-1193 multiplex terminal equipment.

108-2. *SPECIFICATIONS.*

a. The TD-1192 (AN/FCC-98) shall operate as specified in paragraphs 4.3.1.3.3 and 4.3.1.3.3.9 of MIL-STD-188-100.

b. TD-1192 (AN/FCC-98). (CCC-74047)

(1) Asynchronous 50-kb/s data channel tandem performance. With a stable input data rate within 50 kb/s ±250 parts per million provided as an input to the first of three tandemed multiplex terminals, the asynchronous 50-kb/s data shall not exhibit a BER at the data channel output greater than 1×10^{-7} after the multiplex terminals have achieved frame synchronization. With the same stable input data rate, the 50-kb/s data shall not experience any loss of BCI in any of the three multiplex terminals and the slew rate at the output of the 3d multiplex terminal shall not exceed 1 radian over a 3200-bit time period nor 0.1 radian over a 320-bit time period for balanced and unbalanced impedances.

(2) 50-kb/s data channel unbalanced interface characteristics. For the unbalanced interface, the criteria for the 50-kb/s data channel is as follows:

(a) The zero crossing of the positive-to-negative transition of the output timing signal shall occur within ±4 percent of the center of the nominal data unit interval of the output NRZ data signal as shown in figure 102-1.

(b) At the digital input, NRZ data and timing signals shall be detected and processed with the zero crossing of the positive-to-negative transition of the timing signal occurring within ±25 percent of the center of the nominal data unit interval of the NRZ data as shown in figure 15-4.

(3) *50-kb/s data channel peak individual distortion.* For balanced and unbalanced impedances, the peak individual phase distortion of the significant transitions of the output timing signal, when measured at the modulation rate of the 50-kb/s data channel, shall not exceed 5 percent.

108-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Frequency counter.

c. Oscilloscope.

108-4. TEST PROCEDURES.

a. Asynchronous 50-kb/s Data Channel Tandem Performance.

(1) Connect the test equipment as shown in figure 108-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Set up the BER test set for 50-kb/s data operation and transmit a data pattern for 2 minutes. The error rate at the output of the last demultiplexer should not exceed 1×10^{-7}. Record the results on figure 108-2 (USACC Form 679-R).

b. 50-kb/s Data Channel Unbalanced Interface Characteristics.

(1) Connect the test equipment as shown in figure 102-4. Set the 50-kb/s data channel under test for unbalanced operation according to the equipment manual.

(2) Set the BER test set for 50-kb/s data operation. Initially connect the BER test set output to the oscilloscope differential amplifier input. Set the BER test set pattern generator to provide alternating logics 1 and 0.

(3) Set the oscilloscope differential amplifier for 1 mV per division. Set the time base trigger to external, 10 nsec per division.

(4) Adjust the oscilloscope to place a logic 1 level on the reference line of the oscilloscope graticule.

(5) Connect the oscilloscope differential amplifier input to the 50-kb/s data channel transmit data test point. Adjust the oscilloscope differential amplifier V_c control to position the transmit logic 1 on the reference line of the oscilloscope. Record the V_c difference from that established in subparagraph (4), above.

(6) Connect the BER test set output to the oscilloscope differential amplifier. Adjust the oscilloscope V_C control to position a logic 0 on the oscilloscope reference line.

(7) Connect the BER test set output to the data channel input and connect the oscilloscope to the transmit data test point. Adjust the V_C control of the oscilloscope differential amplifier to position the logic 0 to the reference line. Record the V_C difference from that established in subparagraph (6), above.

(8) Connect the oscilloscope to the transmit clock and repeat subparagraphs (2) through (7), above.

(9) Connect the oscilloscope to the receive data test point and repeat subparagraphs (2) through (7), above.

(10) Connect the oscilloscope to the receive clock test point and repeat subparagraphs (2) through (7), above.

(11) Repeat subparagraphs (1) through (10), above, for other 50-kb/s data channels and record the results on the data sheet. Calculate the impedances from the V_C readings and record this value on the data sheet.

c. Phasing.

(1) Connect the test equipment as shown in figure 102-2, if using a frequency counter to measure the difference between the data and timing signals.

(2) Set the multiplex for 24-channel NRZ operation in accordance with the equipment technical manual. Connect channel A of the frequency counter timing module to the MBS transmit data. Connect channel B input to the MBS transmit clock.

(3) Set the frequency counter timing module to time average (A - B), automatic (channel A slope to positive and channel B slope to negative). Set the common-separate-check mode switch of channel B to separate. Adjust the input level controls until a stable display is obtained.

(4) Set the BER test set to provide the required data and clock rates to each digital channel to be tested.

(5) After 5 seconds, record the counter reading on the data sheet. Reset the counter to zero and take another 5-second sample. Repeat this procedure for 10 consecutive readings and record each reading on the data sheet. Average the 10 readings and enter this value on the data sheet.

(6) For the receive end, set the BER test set to provide an alternating 1010 pattern. Connect the receive data and receive clock as shown in figure 102-2. Repeat subparagraph (5), above, and record the results on the data sheet.

NOTE: If available, a vector phase meter may be used.

(7) Repeat subparagraphs (1) through (6), above, for all remaining 50-kb/s data channels, except for the 0- to 20-kb/s channel modules.

(8) If using an oscilloscope, connect the test equipment as shown in figure 102-2 and proceed as follows:

(a) Set the multiplex for maximum channel operation and NRZ format.

(b) Connect the BER test set to the input of the data channel under test. Set the data and clock to the applicable data rate. Set the BER test set to provide an alternating 1010 pattern to the input of the device to be tested.

(c) Connect channel A of the oscilloscope to the transmit data output and adjust the controls to provide a stable display at the reference line. Connect channel B to the transmit timing output and adjust for a stable display.

(d) Measure and record the time difference between the trailing edge (logic 1 to 0 transition) of the timing signal and the center of the nominal unit interval of the transmit data stream as shown in figure 102-1. Measure and record the time difference between the leading edge (0 to 1 transition) of the timing signal and the transition of the transmit data signal as shown in figure 102-1.

(e) Repeat subparagraphs (a) through (d), above, with the oscilloscope connected to the receive MBS data and clock.

d. Sampling.

(1) Connect the test equipment as shown in figure 102-2.

(2) Set the BER test set for the required data and clock rates with a 1010 pattern and NRZ format. Set the BER test set for a clock offset of 25 percent of the nominal data unit interval as shown in figure 15-4. Measure this offset with the oscilloscope and compare the measured value to that displayed on the BER test set.

(3) Transmit data for 1 minute and observe that the error rate does not increase over that obtained without the clock offset. Also note that the terminal equipment does not lose frame synchronization. Record the results on the data sheet.

(4) Return the BER test set clock offset to normal. Set the transmit data pattern to 25-percent offset from the nominal unit interval. Repeat subparagraph (3), above.

(5) Repeat subparagraphs (1) through (4), above, for the remaining 50-kb/s data channels.

e. 50-kb/s Data Channel Peak Individual Distortion.

(1) Set the BER test set for 50-kb/s data and clock rates. Connect the unit to the channel under test. Set the BER test set to provide a 50-kb/s pattern signal to the channel input.

(2) Refer to figure 102-2 and set the frequency counter as follows:

(a) Time average to A - B.

(b) Time base to automatic.

(c) A-slope to positive.

(d) B-slope to negative.

(e) Mode to common B.

(3) Connect the counter input B to the receive clock. After 5 seconds, record the results on the data sheet.

108-5. DATA RECORDING AND ANALYSIS.

a. Review all test data for completeness and accuracy. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

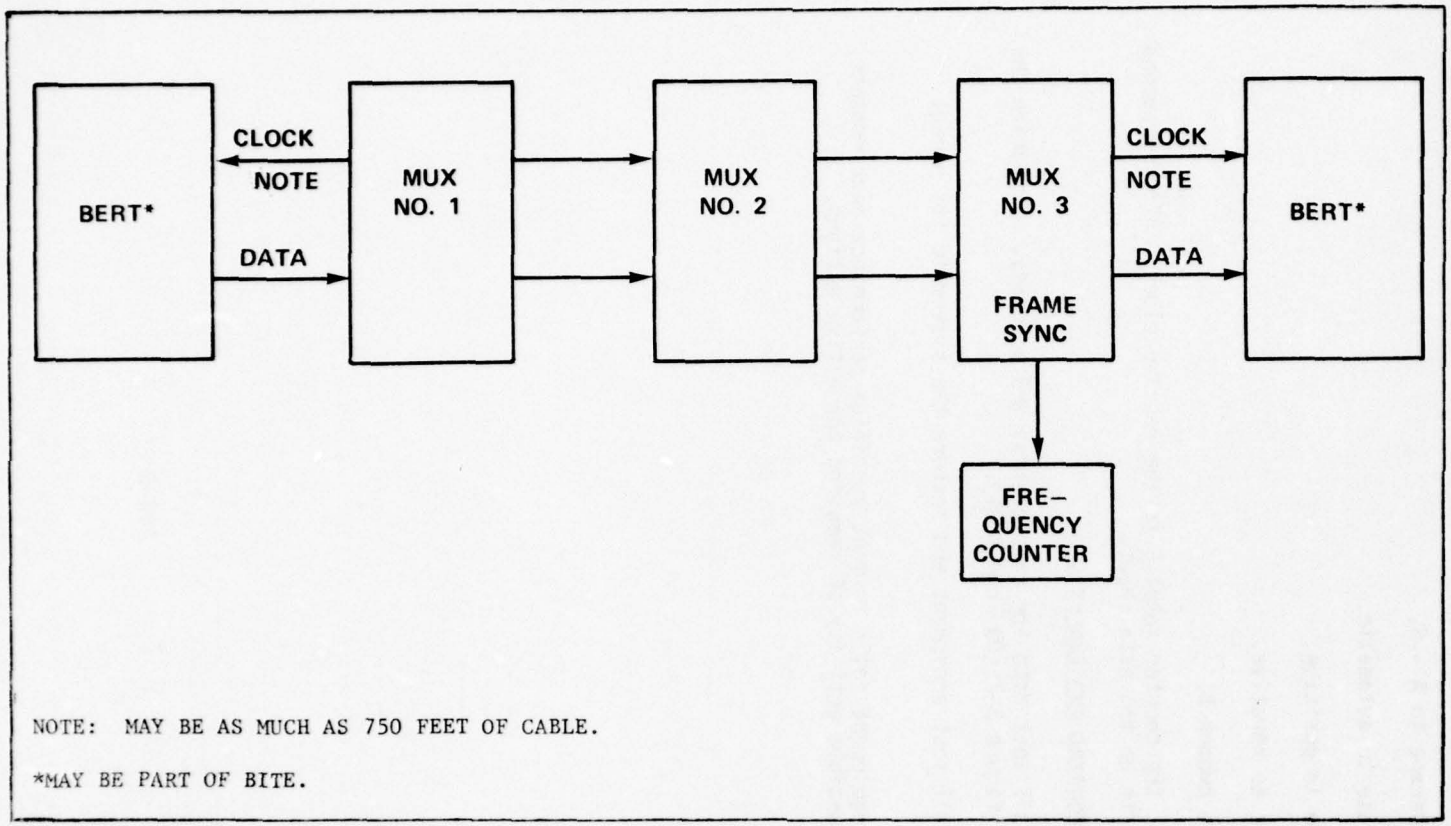


Figure 108-1. 50-kb/s data channel test setup.

50 kb/s DATA CHANNEL PERFORMANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		BALANCED ☐ UNBALANCED ☐	FORMAT NRZ ☐ BIPOLAR ☐
DATA BIT RATE		CHANNEL	LINK ☐ LOOP ☐
TANDEM OPERATION		BER	LOSS OF BCI YES ☐ NO ☐
PARAMETER		MEASURED	REQUIREMENT
RISE TIME (μsec)			
FALL TIME (μsec)			
PULSE WIDTH LOGIC 1 (+)			
PULSE WIDTH LOGIC 0 (-)			
PULSE AMPLITUDE LOGIC 1			
PULSE AMPLITUDE LOGIC 0			

XMT DATA	LOGIC 1 V_c VOLTS	LOGIC 0 V_c VOLTS	IMPEDANCE
XMT CLOCK			
RCV DATA			
RCV CLOCK			

PHASING	COUNTER READING	AVERAGE

CLOCK OFFSET 25%	BER:
DATA OFFSET 25%	BER:
TIMING DISTORTION	%
COMMENTS	

USACC FORM 679-R
1 MAY 79

Figure 108-2. 50-kb/s data channel performance data sheet.

CHAPTER 109

LOCKUP AND INTERFACE PROTECTION (MULTIPLEX) (DT-306)

109-1. GENERAL.

a. The purpose of this test is to demonstrate the lockup and interface protection requirements of the multiplex terminal equipment.

b. This test may be performed on contractor EF&I systems to verify that they conform to specified performance parameters. It may also be used by installer or quality assurance personnel during onsite test activities as directed. However, it would normally be performed during initial equipment acquisition.

109-2. SPECIFICATIONS.

a. Interface protection shall be provided so that any driver or terminator shall not be damaged by the occurrence of interface protection. (MIL-STD-188-100)

(1) Shorting of the input or output leads to ground or to each other.

(2) Crossing of the leads with any physical leads of the interface.

(3) Opening of either or both of the input or output leads.

b. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) *Lockup protection.* The operation of the multiplex terminal shall be such that when a 25-volt output pulse as described below is applied simultaneously to any combination of input/output leads. No logic lockup shall occur that results in service outage or degraded performance requiring manual intervention to restore service. The rise time of the voltage pulse shall be 0.5 volt/nsec with a duration of 1 µsec between the 50-percent amplitude points.

(2) *Interface protection.* Interface protection shall be as specified in subparagraph a, above.

c. The TDM (TD-1193) shall provide the following levels of protection. (CCC-74048)

(1) *Lockup protection.* Same as subparagraph b(1), above.

(2) *Interface protection.* Same as subparagraph a, above, with voltage magnitudes of 25 volts on the terminator leads.

d. The multiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

109-3. TEST EQUIPMENT REQUIRED.

a. BER test set.

b. Oscilloscope.

c. Pulse generator HP 214.

d. Oscillator.

e. 1020-Hz filter.

f. Cables, terminators, connectors, etc., as required.

g. Splitter.

109-4. TEST PROCEDURES.

a. Lockup Protection.

(1) Connect the test equipment as shown in figure 109-1 and allow approximately 30 minutes for warmup and stabilization.

(2) Connect the BER test set pattern generator to the highest data rate channel for which the multiplex has been configured. Set the BER test set data output and clock rate to correspond to the channel under test. With the pattern generator, transmit 2 minutes of data.

(3) At the receive end, measure the error rate with the error detector and record this value on figure 109-2 (USACC Form 680-R). This will be the reference level for the remaining test sequences.

(4) Set up the pulse generator to provide a 25-volt output pulse as measured with the oscilloscope. Adjust the pulse generator width and duration for 0.5 volt/nsec with a duration of 1 μsec between the 50-percent amplitude points.

(5) Connect the pulse generator output to the multiplex terminal transmit data input. Set the pulse generator for manual (single pulse) operation. Press the manual pulse control of the generator to provide a single 25-volt pulse on the transmit data input leads.

(6) Remove the pulse generator and perform a BER test as outlined in subparagraphs (2) and (3), above. Compare the BER to the established reference level and record the results on the data sheet. Verify that the multiplex returns to normal operation without manual intervention.

(7) Repeat subparagraphs (4) through (6), above, for each input and output lead of the multiplex terminal as shown on the data sheet.

NOTES: 1. If a splitter is available, the pulse may be applied to more than one input/output simultaneously.

2. If the multiplex terminal contains voice frequency channels, establish an S/Nq distortion reference level by performing DT-276, and repeat the test after each sequence on a selected channel.

b. Interface Protection. Perform subparagraph a(2), above, on the input/output leads and verify that damage or degradation has not occurred. Record the results on the data sheet.

109-5. DATA RECORDING AND ANALYSIS.

a. Review all test results to verify that the equipment sustained no damage and met the established performance level at the conclusion of each test sequence. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the unit fails to meet specified performance requirements or sustains damage, notify the responsible activity of required corrective actions.

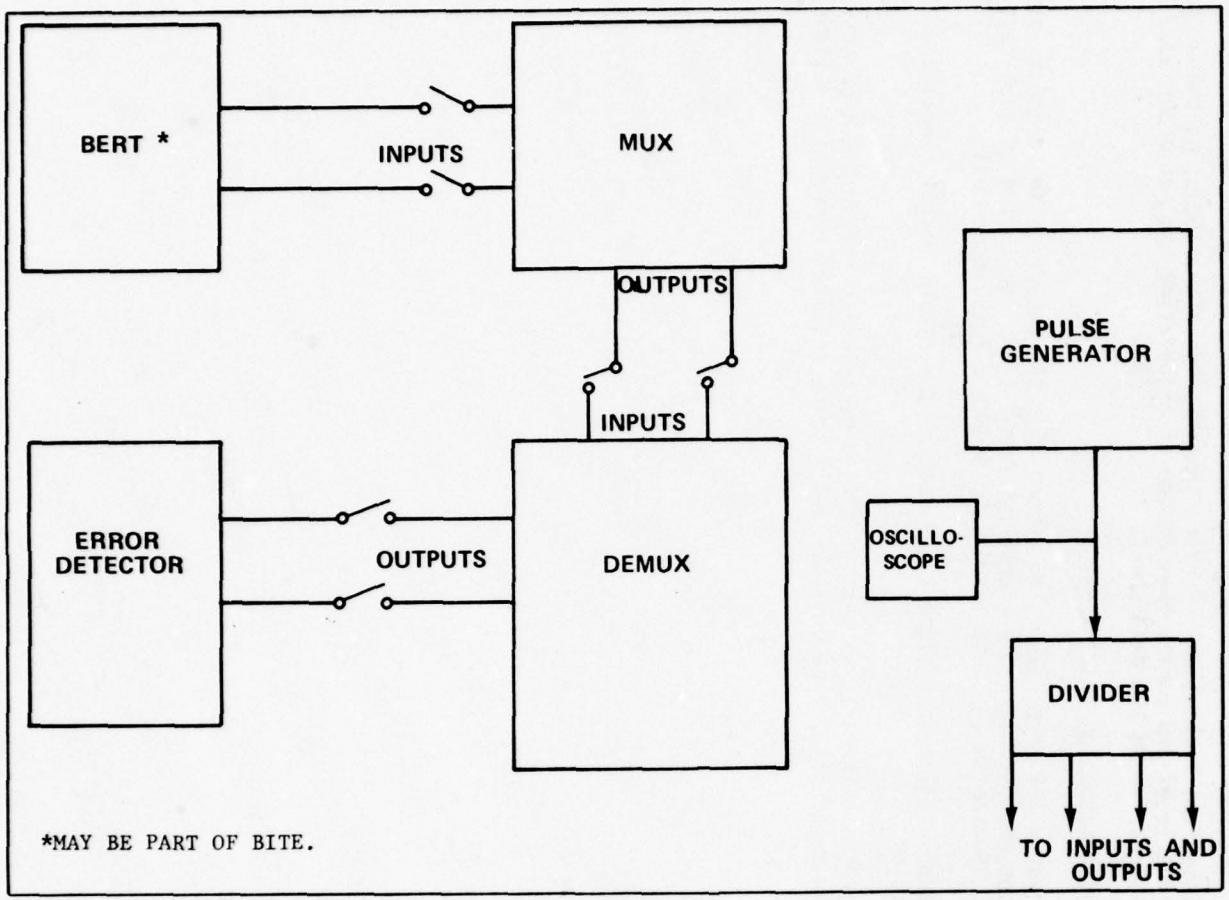


Figure 109-1. Lockup and interface protection (multiplex) test setup.

LOCKUP AND INTERFACE PROTECTION (MULTIPLEX) (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO., YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		FORMAT NRZ ☐ BIPOLAR ☐	REF S/Nq dB
TEST POINT(S)		BER REF LEVEL	FINAL BER
XMT CLOCK			
XMT DATA			
RCV CLOCK			
RCV DATA			
DATA CHANNEL(S)			
INPUT SHORTED			
OUTPUT SHORTED			
INPUT/OUTPUT CROSSED			
INPUT/OUTPUT OPEN			
S/Nq		dB	
COMMENTS			

USACC FORM 680-R
1 MAY 79

Figure 109-2. Lockup and interface protection (multiplex) data sheet.

CHAPTER 110

TIME DIVISION MULTIPLEX INTERFACE CHARACTERISTICS AND PERFORMANCE (DT-307)

110-1. GENERAL.

a. The purpose of this test is to demonstrate and verify the interface characteristics and performance of the TD-1193 TDM.

b. This test may be performed on contractor EF&I systems to verify that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. It is, however, more applicable during initial equipment acceptance than routine onsite testing.

110-2. SPECIFICATIONS. The following criteria applies to the TD-1193. (CCC-74048)

a. TDM Port Interface. When the TDM is configured in tandem, the interface equipment shall acquire synchronization within 300 msec or less and maintain synchronization for 2 hours. In addition, when the interface equipment is looped via this tandem connection the following applies:

(1) The BER performance of 50-kb/s data transmission via data interleaving cards of the TD-1192 (AN/FCC-98) (synchronous and asynchronous) and the TSEC/HY-12 with the HN-74 shall not be worse than that obtained when any of the equipment is looped back upon itself.

(2) The S/Nq and idle channel noise of voice channels provided via the D2/D3 channel banks shall meet their applicable specifications.

(3) The BER's of 1.544, 3.088, and 6.176 mb/s data transmitted via the TSEC/KG-81 shall not be worse than that obtained for the TSEC/KG-81 looped back upon itself.

All of the above requirements shall be met using bipolar and NRZ plus timing interface except the TSEC/KG-81 to which only the NRZ plus timing interface applies.

b. Tandem Operations. With a stable input data rate (within the tolerance shown in table 110-1) provided to the first of five consecutive multiplexing and five consecutive demultiplexing functions using three or more TDM's, there shall be no loss of BCI in any of the equipment (fig. 110-1).

Table 110-1. TDM Data Port Input Tolerance

PORT INPUT (mb/s)	MODE	TOLERANCE (b/s)
1.544	Asynchronous	±200
1.544	Synchronous	--
3.088*	Asynchronous	±400
6.176*	Asynchronous	±600
3.088*	Synchronous	--
6.176*	Synchronous	--
12.352*	Synchronous	--

*Strapped ports.

c. TDM MBS Interface. The MBS of the TDM shall interface with the TSEC/KG-81 and/or AN/FRC-( ) radios (fig. 110-2) at all data rates specified in table 110-2 such that the resultant combination meets the requirements of subparagraph d, below.

Table 110-2. Combined Input vs Corresponding MBS Rate

COMBINED INPUT RATE (mb/s)	MBS RATE (mb/s)	
1.544	3.232	6.464
3.088	3.232	6.464
4.632	6.464	9.696
6.176	6.464	9.696
7.720	9.696	12.928
9.264	9.696	12.928
10.808	12.928	
12.352	12.928	

d. MBS Interface. When the MBS of a TDM is interconnected with two back-to-back AN/FRC-( ) radios (with an input RSL to the receiver corresponding to a BER not exceeding $1x10^{-9}$) or a TSEC/KG-81 (fig. 110-3 USACC Form 681-R), the BER of any TDM port shall not be increased from that measured when the TDM is looped back upon itself.

e. Performance Characteristics. Unless otherwise directed, the following requirements apply when two TDM's are connected as a system or when the TDM MBS output is connected to the input (back-to-back) using any cable (RG-108A/U, 78 or 100 ohms) length up to and including 100 feet. The port side of the TDM shall operate with any cable lengths up to and including 750 feet for data rates less than 2 mb/s and with any cable lengths up to and including 100 feet at data rates above 2 mb/s as indicated below.

(1) *Port characteristics.* The TDM shall be configured to operate with as many as eight full duplex ports operating at nominal data rates of 1.544 mb/s for a single port; 3.088 mb/s in place of two 1.544-mb/s ports; and 6.176 mb/s in place of four 1.544-mb/s ports or any combination thereof. The

combined input rate shall not be greater than 12.352 mb/s (8 times 1.544 mb/s). The relationship between the combined input rate of all TDM ports and the corresponding MBS rate is shown in table 110-2.

(2) *1.544-mb/s ports.* A port of the TDM shall operate within a full duplex data rate of 1.544 mb/s ±200 b/s in the asynchronous mode and 1.544 mb/s in the synchronous mode. In the synchronous mode, the port input rate shall be synchronous with the timing output. The TDM ports shall interface with NRZ data signals with associated timing or with bipolar signals (50-percent duty cycle). When operating with a bipolar signal, timing shall be extracted from the bipolar signal.

(3) *Port strapping.* The TDM shall operate at data rates of 3.088 mb/s ±400 b/s and 6.176 mb/s ±600 b/s in the asynchronous mode, and at 3.088 mb/s and 6.176 mb/s in the synchronous mode. In the synchronous mode, the rate of strapped ports shall be synchronous with the timing output in subparagraph (4), below. Operation at the digital data rates of 3.088 and 6.176 mb/s shall be in place of two and four 1.544-mb/s ports, respectively. Strapped ports shall interface on an NRZ and timing signal basis as outlined in DT-300.

(4) *Synchronous port service timing.* The TDM shall provide a source timing output at 1.544 MHz for each 1.544-mb/s synchronous port, and at 3.088 and 6.176 MHz for each 3.088- and 6.176-mb/s synchronous strapped port as shown in figure 110-2. Provisions shall be included to adjust the phasing between timing out and data in. The source timing output signal shall meet the polar square wave requirements outlined in DT-300.

110-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. Oscillator.

c. Noise measuring set.

d. Frequency counter.

e. BER test set.

f. Mixer.

g. Voltmeter.

h. Adapters, cables, and connectors, as required.

110-4. TEST PROCEDURES.

a. TDM Port Interface and Tandem Performance.

(1) Connect the equipment as shown in figure 110-1 and allow approximately 30 minutes for warmup and stabilization.

NOTE: The TD-1193 (1 through 5 in figure 110-1) may represent three or more multiplexers/demultiplexers with a specific number of ports (input and output) looped at the port side.

(2) At the receive demultiplexer (TD-1192 (AN/FCC-98)), connect input A of the frequency counter to the demultiplex inhibit test point and input B to the loss-of-frame synchronous test point. Perform DT-298 and verify that the TD-1192 acquires synchronization within 300 msec. Record the results on figure 110-3 (USACC Form 681-R). Verify that the equipment remains in synchronization for at least 2 hours.

(3) On the TD-1192 (AN/FCC-98), replace a voice frequency card with a 50-kb/s data interleaving card. Connect the BER test set pattern generator to the 50-kb/s data channel input.

(4) Patch the data and clock output of the HN-74 transmit to the receive input of the HN-74. After the equipment has acquired frame synchronization, transmit data for approximately 5 minutes and observe the error rate at the receive channel output. Record this as the BER reference level on figure 110-3 (USACC Form 681-R).

(5) Connect the audio oscillator to a voice frequency channel input as shown in figure 110-1. At the receive end, measure the idle channel noise and S/Nq as described in DT-265 and DT-276 respectively. Record the results as the BER reference level on figure 110-3 (USACC Form 681-R).

(6) Remove the back-to-back patch from the HN-74 to the TD-1193 as shown in figure 110-1. Repeat subparagraphs (4) and (5), above.

(7) Establish a TSEC/KG-81 transmit-to-receive loopback and connect the BER test set to the TSEC/KG-81 input. Set the BER test set to transmit a 1.544-mb/s pattern and record the back-to-back error rate reference level. Repeat for data rates of 3.088 and 6.176 mb/s.

(8) Reconnect the TSEC/KG-81 to the TD-1193 input/output. Connect the BER test set to the 1.544-mb/s port. Transmit a pattern for approximately 5 minutes. At the receive end, record the number of errors on figure 110-3 (USACC Form 681-R). This will be the measured BER.

(9) In turn, strap the TD-1193's for two-port (3.088 mb/s) and four-port (6.176 mb/s) operation. Repeat the BER test. Record the results on figure 110-3 (USACC From 681-R).

(10) Repeat subparagraphs (1) through (9), above, with the TD-1193 and interface equipment configured for NRZ and bipolar operation as described in paragraph 110-2a, above.

b. TDM MBS Interface.

(1) Connect the TD-1193 in a local loop and perform a BER test on one port or strapped port. Record the results as the reference BER on figure 110-3 (USACC Form 681-R).

(2) Connect the TD-1193, TSEC/KG-81, and AN/FRC-( ) radios in a loop configuration as shown in figure 110-2.

NOTE: The input/output of the TD-1193 may include the cable described in paragraph 110-2e, above.

(3) Adjust the RSL to provide an equivalent BER of $1x10^{-9}$ as outlined in DT-226.

(4) Perform a BER test on one port or strapped port and compare the results to those obtained in subparagraph (1), above. Record the results on figure 110-3 (USACC Form 681-R).

(5) Repeat subparagraphs (1) through (4), above, for each of the data rates shown in table 110-1.

c. Synchronous Port Source Timing.

(1) Connect the TDM for synchronous port operation. With the frequency counter, measure the timing output frequency.

(2) Perform DT-300 on the receive timing output and record the results on figure 103-2 (USACC Form 674-R).

(3) With the oscilloscope, verify that the phasing betweeh the timing out and the data in can be adjusted for minimizing delay.

(4) Record the results on figure 103-2 (USACC Form 674-R).

110-5. DATA RECORDING AND ANALYSIS.

a. Review all data for completeness and accuracy. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the equipment fails to meet specified requirements, notify the responsible activity of required corrective actions.

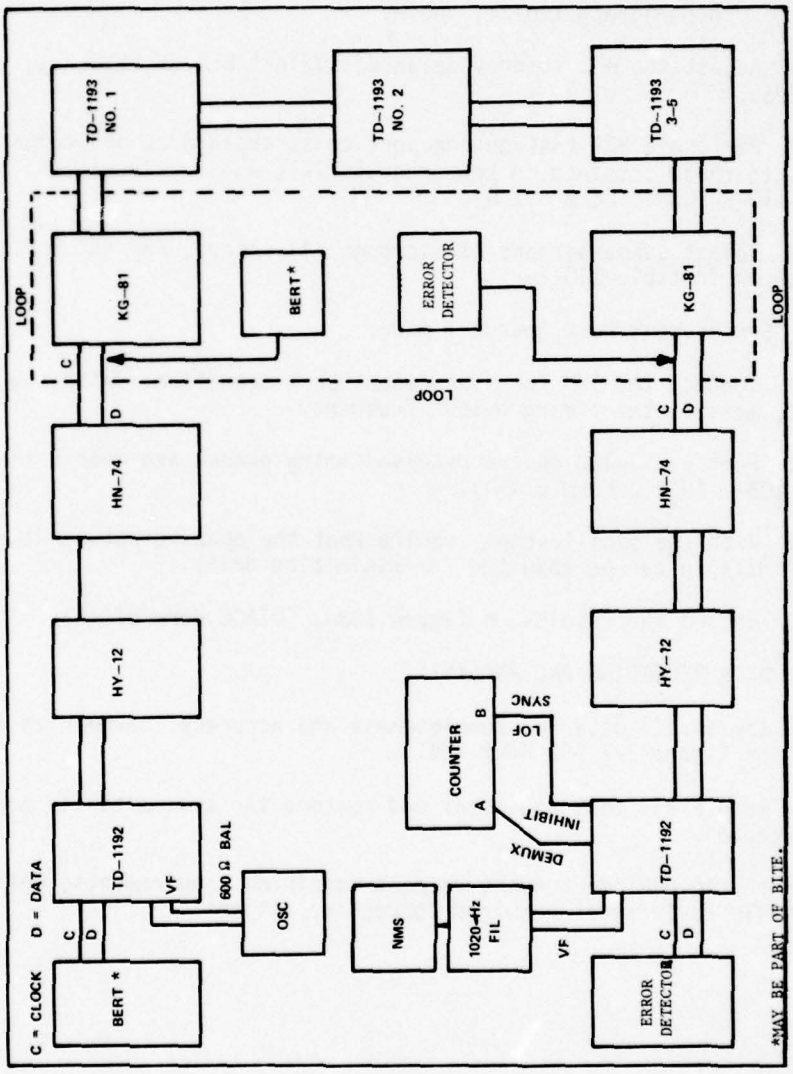


Figure 110-1. Tandem test setup.

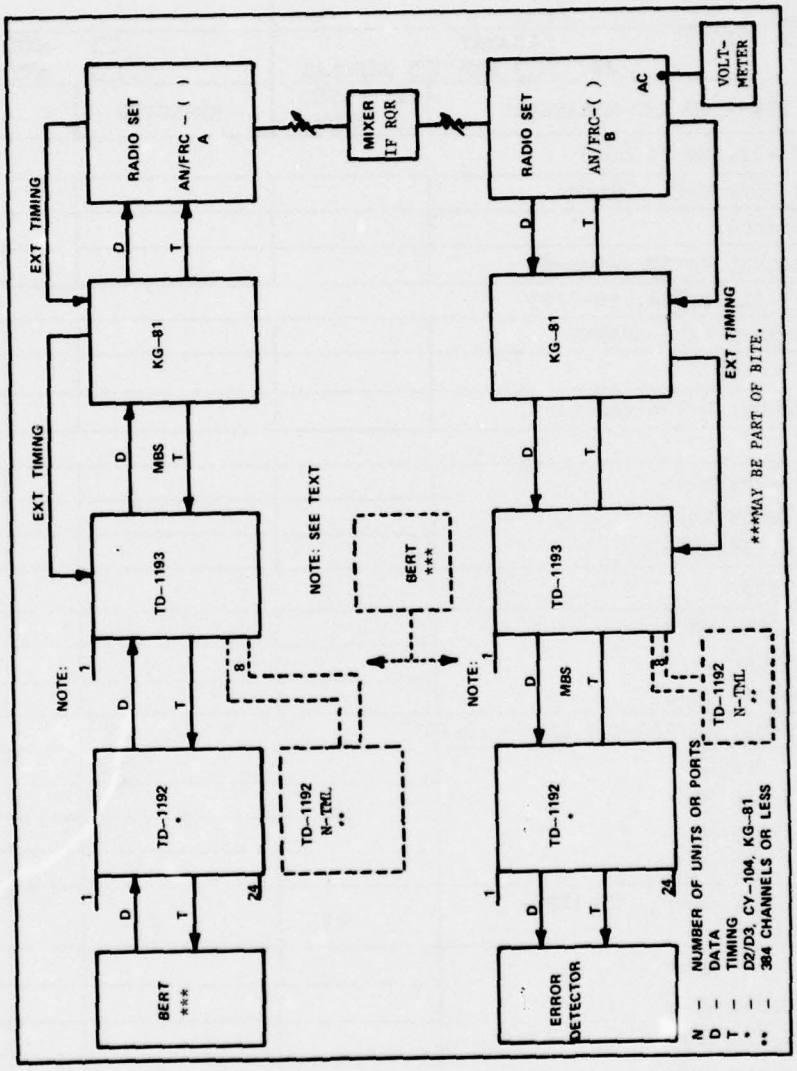


Figure 110-2. TDM MBS interface test setup.

CCP 702-11

TIME DIVISION MULTIPLEX INTERFACE & PERFORMANCE (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (DAY, MO, YEAR)		
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGR SIGNATURE		
RSL FOR BER $1x10^{-9}$ dBm		FORMAT ☐ NRZ ☐ BIPOLAR	☐ SYNC ☐ ASYNC		
CONFIGURATION AND PARAMETER		REF LEVEL OR REQT	MEASURED	C	NC
TD-1192, HY-12, HN-74 LOOP					
BER 50-kb/s DATA CHANNEL					
S/Nq (dBrnc0)					
IDLE CHANNEL NOISE (dBrnc0)					
TD-1192, HY-12, HN-74, TD-1193					
BER 50-kb/s DATA CHANNEL					
S/Nq (dBrnc0)					
IDLE CHANNEL NOISE (dBrnc0)					
KG-81 LOOP					
BER 1.544 mb/s					
3.088 mb/s					
6.176 mb/s					
KG-81, TD-1193					
BER 1.544 mb/s					
3.088 mb/s					
6.176 mb/s					
TD-1193, KG-81, AN/FRC-( ) RSL ≈ $1x10^{-9}$					
BER 1.544 mb/s					
3.088 mb/s					
6.176 mb/s					
12.352 mb/s					
TD-1192, HY-12, HN-74, TD-1193, AN/FRC-( ) LINK		RSL	dBm		
BER 1.544 mb/s					
3.088 mb/s					
6.176 mb/s					
12.352 mb/s					
ICN (dBrnc0)					
S/Nq (dBrnc0)					
TIMING OUTPUT FREQUENCY (TD-1193)					
TIMING INTERFACE (DT-300)					
PHASING					

USACC FORM 681-R
1 MAY 79

Figure 110-3. TDM interface and performance data sheet.

CHAPTER 111

MULTIPLEX/DEMULTIPLEX INPUT POWER (DT-308)

111-1. GENERAL.

a. The purpose of this test is to demonstrate the performance of the multiplex/demultiplex terminal equipment under different input power levels and frequencies.

b. This test may be performed on contractor EF&I systems to ensure that they meet specified requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed. However, it would not normally be performed during onsite testing since it primarily verifies design specifications.

c. Equipment input power requirements should be consulted before conducting the testing.

111-2. SPECIFICATIONS.

a. The following criteria applies to the TD-1192 (AN/FCC-98). (CCC-74047)

(1) The multiplex equipment shall operate from two power sources.

(a) A station battery of -48 VDC with an allowable range of -44 to -56 VDC or any variation thereof, and a ripple and noise as high as 100 mV (peak-to-peak).

(b) A power source of 117/230 VAC ±10 percent (single phase) with a frequency of 47 to 420 Hz.

(2) The input power shall not exceed 150 watts including data interleaving options.

(3) Line protection devices shall be incorporated to provide overload protection for the input powerline.

(4) Each power input connector and cable shall contain a separate equipment grounding wire.

b. The TD-1193 shall conform to paragraphs 111-2a (1) through (4), above, except that the input power shall not exceed 300 watts and the AC input power requirements does not apply.

c. The AN/FRC-162 and VICOM 4000-2 system shall operate satisfactorily at 115 VAC or -48 VDC with input lines protected.

d. The multiplex/demultiplex equipment shall operate as specified in the standard engineering plan or contract specifications.

111-3. TEST EQUIPMENT REQUIRED.

a. Oscilloscope.

b. Frequency counter.

c. AC variable power supply (frequency).

d. Autotransformer.

e. BER test set.

f. Oscillator.

g. Noise measuring set.

h. Voltmeter.

i. Wattmeter.

j. Ammeter.

111-4. TEST PROCEDURES. Connect the test equipment as shown in figure 111-1 and allow approximately 30 minutes for warmup and stabilization.

a. AC Voltage Input.

(1) Configure the multiplex terminal for 117-VAC, 60-Hz operation by proper strapping and switching on the power unit.

(2) Connect the BER test set to the channel input of the highest data rate channel in the multiplexer. Set the data and clock rates to correspond to the channel input under test. Transmit data for 2 minutes. At the receive end, record the number of errors as a reference value on figure 111-2 (USACC Form 682-R).

(3) Connect the oscillator to the voice frequency channel input and adjust the frequency for 1020 Hz at a level corresponding to the test point being used. If the transmission line is out of service, this level will normally be 0 dBm0.

(4) Place the voice frequency channels of the multiplex off-hook. Measure the S/Nq as described in DT-276. Record this measurement as the reference value for the AC input.

(5) Adjust the AC variable frequency power supply for the voltages and frequencies shown on the data sheet. Repeat subparagraphs (2) through (4), above, for each change in voltage and frequency.

(6) Configure the multiplex for 230-VAC operation. Adjust the AC variable frequency power supply for the voltages and frequencies shown on the data

sheet. Repeat supbaragraphs (2) through (4), above, for each change in voltage and frequency.

(7) At each input power and frequency change, record the input power as reflected on the voltmeter.

NOTE: The above voltages and frequencies are typical of the requirements for the TD-1192. If testing other types of equipment, consult the equipment performance specifications before testing.

(8) Verify that the multiplex terminal has input line protection devices installed and that each connector and cable input powerline contains a separate grounding wire.

(9) With the oscilloscope, measure and record the ripple voltage for each voltage and frequency input level.

b. DC Operation.

(1) Configure the multiplex terminal for DC operation. Adjust the DC input supply to provide -48 VDC as read on the digital voltmeter.

(2) Perform BER and S/Nq tests as outlined in paragraphs 111-4a (2) through (4), above. Record the results as the DC reference level.

(3) Adjust the DC input voltage for -44 VDC. Repeat paragraphs 111-4a (2) through (4), above.

(4) Adjust the DC input voltage to -56 VDC. Repeat subparagraph (3), above.

(5) Record the power consumed as reflected on the wattmeter for the -44, -48, and -56 VDC input levels.

(6) With the oscilloscope, measure and record the peak-to-peak ripple noise for each input power level.

(7) Verify that the input powerline has protective devices installed, and that a separate ground wire is provided at each input connector.

111-5. DATA RECORDING AND ANALYSIS.

a. Verify that all recorded data is accurate and within specifications. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the unit fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

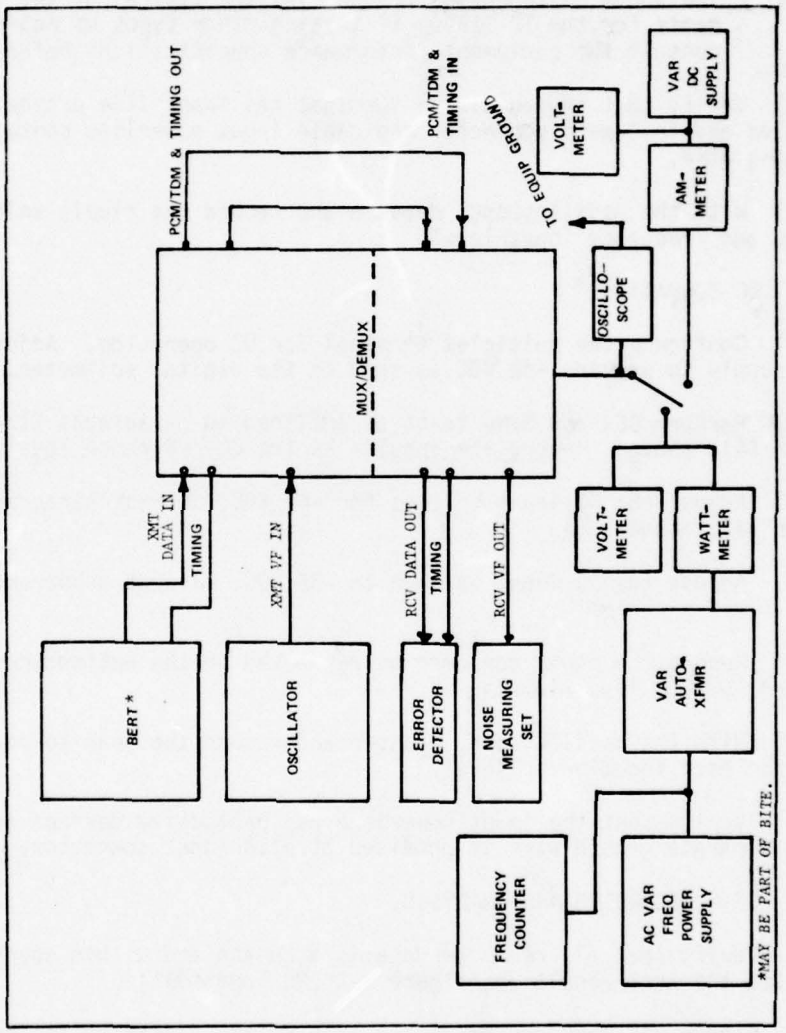


Figure 111-1. Multiplex/demultiplex input power test setup.

POWER INPUT CHARACTERISTICS (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT		REFERENCE INPUT -48 VDC BER _____ S/Nq _____	117 VAC 60 Hz BER _____ S/Nq _____

PARAMETER (INPUT)	BER	S/Nq	POWER (WATTS)	RIPPLE (VOLTS)	C / NC
105.3 VAC 60 Hz					
128.7 VAC 60 Hz					
105.3 VAC 47 Hz					
128.7 VAC 47 Hz					
105.3 VAC 420 Hz					
128.7 VAC 420 Hz					
207 VAC 60 Hz					
230 VAC 60 Hz					
253 VAC 60 Hz					
207 VAC 47 Hz					
230 VAC 47 Hz					
253 VAC 47 Hz					
207 VAC 420 Hz					
230 VAC 420 Hz					
253 VAC 420 Hz					
-44 VDC					
-56 VDC					
INPUT PROTECTION					
SEPARATE GROUND					
OTHER INPUT LEVELS					

COMMENTS

NOTE: C = COMPLIANCE; NC = NONCOMPLIANCE.

USACC FORM 682-R
1 MAY 79

Figure III-2. Power input characteristics data sheet.

CHAPTER 112

BATTERY PLANT (DT-309)

112-1. GENERAL.

a. The purpose of this test is to demonstrate that the station battery plant meets or exceeds the design capacity (ampere-hour rating) specified by the supplier and that the capacity provided is in accordance with the standard engineering plan.

b. The voltages referred to in the procedure are typical. However, test personnel should consult the battery technical data before performing the test. The voltage and current, as reflected on the equipment panel meters, may be verified during testing using an external voltmeter and clamp-on ammeter.

c. Once this test has been performed at a specific location, it should not be necessary to demonstrate the battery plant performance during routine follow-on testing.

d. The batteries provided for the AN/FRC-162 and VICOM 4000-2 system are float service type with an expected 20-year service life. They are capable of supplying power to the complete technical load for 4 hours minimum at a manned site and 8 hours at an unmanned site.

e. This test may be performed on contractor EF&I systems to verify that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

112-2. SPECIFICATIONS.

a. The station battery plant shall conform to the standards outlined in MIL-HDBK-411.

b. In a fully-charged condition, the capacity of the station battery plant for the AN/FRC-162 and VICOM 4000-2 system furnished at each site shall be capable of continuously providing the full DC operational load plus 25 percent. Discharge time of a fully-charged battery plant to a final battery voltage of -42.0 volts, under full operational load plus 25 percent, shall be 8 hours minimum at 25 degrees Centigrade ambient temperature.

NOTE: At a manned site, discharge time could be as little as 4 hours.

c. The station battery plant shall conform to the requirements of the standard engineering plan or contract specifications.

WARNING

WHEN MIXING ELECTROLYTE, THE ACID SHOULD ALWAYS BE ADDED TO THE WATER.

CAUTION

IF ELECTROLYTE COMES IN CONTACT WITH THE SKIN, THE AFFECTED AREA SHOULD BE FLUSHED WITH WATER, AND MEDICAL ATTENTION SHOULD BE OBTAINED IMMEDIATELY. IF THE ELECTROLYTE GETS INTO THE EYES, THE EYES SHOULD BE FLUSHED WITH WATER FOR AT LEAST 15 MINUTES, AND MEDICAL ATTENTION SHOULD BE OBTAINED IMMEDIATELY.

112-3. TEST EQUIPMENT REQUIRED.

a. Voltohmmeter.

b. Hydrometer.

c. Clamp-on ammeter.

112-4. TEST PROCEDURES.

a. Pretest Conditions.

(1) Fully charge the batteries before conducting the battery load test.

NOTE: All cell voltages and hydrometer readings taken at completion of the initial charge must be within the limits specified for a fully-charged battery being maintained on float as contained in the manufacturer's literature for the specific battery under test.

(2) Connect the station load and maintain the battery on float by the charger source. Connect one charger to the battery bus during the test.

(3) Record the following information on figure 112-1 (USACC Form 683-R) before starting the test.

(a) Charger DC bus voltage.

(b) Technical DC bus voltage.

(c) Technical DC bus amperes.

b. Measurements.

(1) Disconnect the AC input to the battery chargers.

(2) Record the time on the data sheet and verify that the battery is on discharge. Charger voltmeters should read approximately -48 VDC.

(3) Record charger DC and technical bus volts at hourly intervals until each reaches a final value of -42.0 volts. Record the elapsed time from the start of the test.

(4) Refer to figure 112-2 to determine the minimum time on discharge for the battery load at which the test was conducted. The actual time required to discharge the battery to -42.0 volts should equal or exceed the time for that load. The individual cell voltages should be 1.75 VDC.

(5) Measure and record the station load in amperes for the site under test. If the measured load does not exceed the current value of column 6, table 112-1, the battery meets the station design load requirements.

Table 112-1. Station Battery Design Data

STATION (COL 1)	100% LOAD PLUS 25% EXPANSION (COL 2)	MIN RQR EMER BTRY TIME IN HOURS (COL 3)	BTRY DESIGN LOAD IN AMP-HR (COL 2 x COL 3) (COL 4)	BTRY AMP-HR CAP FURN (COL 5)*	80% OF BTRY AMP DISCHARGE RATE (COL 6)**
X	65	8	520	595	59.5

*At 77°F, deliver the minimum ampere-hour at a constant discharge rate, based on the discharge time in column 3, to a final voltage of 1.75 per cell.

**Percentage of discharge rate is 80% of the ampere-hour capacity of the battery furnished (col 5) divided by the required emergency discharge time (col 3).

112-5. DATA RECORDING AND ANALYSIS.

a. Review the recorded data for completeness and accuracy. Summarize the test results on figure 3-7 (*DD Form 2091*).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the battery plant fails to meet specified performance requirements, notify the responsible activity of required corrective actions.

CCP 702-11

BATTERY PLANT (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
BATTERY TYPE		MFD BY	AMPERE-HOUR & TEMP
STATION LOAD AMPS		SPECIFICATION	FINAL CELL VOLTAGE
CHARGER DC BUS VDC		TECHNICAL DC BUS VDC	TECHNICAL DC BUS AMPS

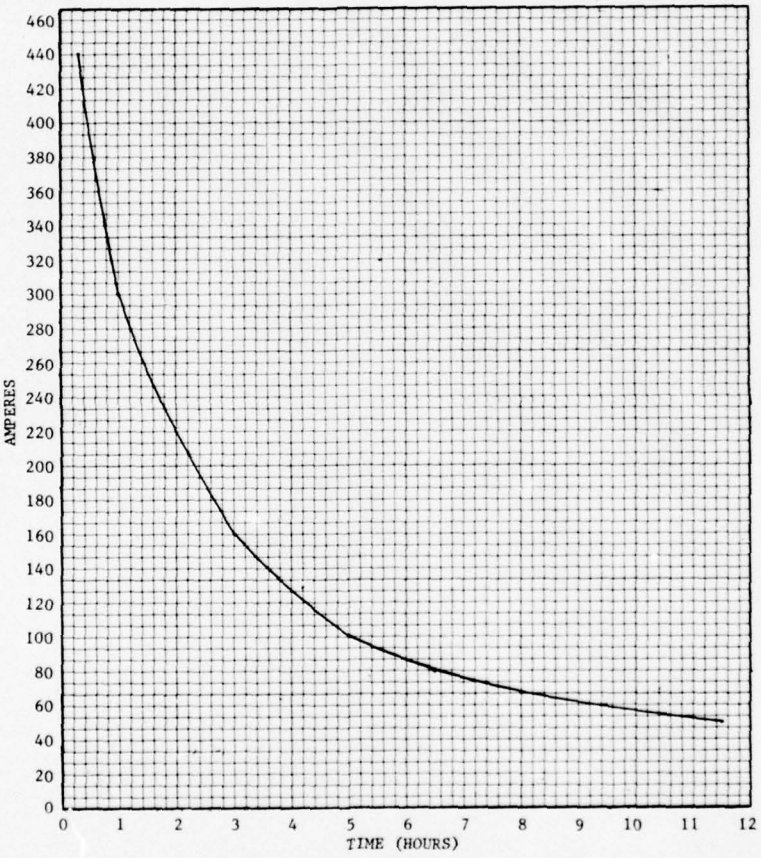
TIME	LOAD BUS	DC BUS	TIME	LOAD BUS	DC BUS

COMMENTS

USACC FORM 683-R
1 MAY 79

Figure 112-1. Battery plant data sheet.

GENERAL PURPOSE GRAPH PAPER DATA SHEET G-10			PAGE _____ OF _____ PAGES DATE (day, mo., year)
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR. SIGNATURE
TITLE OF PERFORMANCE PLOTTED Battery Plant Discharge Data			TEST NO. DT-309



DD FORM 2094

Figure 112-2. Typical discharge curve of load current at 77°F to final voltage per cell of 1.75 (24 cells).

CHAPTER 113

DC POWER AND DISTRIBUTION SYSTEM (DT-310)

113-1. GENERAL.

a. The purpose of this test is to measure and demonstrate the performance of the DC power and distribution system.

b. Basically, the procedures cover the DC/AC inverters, rectifiers, chargers, and the operation of the system under various conditions.

c. Portions of the procedures are more applicable to design verification at the time of initial equipment delivery while others are applicable during onsite test activities. Design verification testing would not normally be performed during routine field testing.

d. Controls, indicators, and meters may vary from manufacturer to manufacturer; therefore, test personnel should consult the applicable equipment literature to determine the presence of various indicator lamps, controls, and panel meters. Typical controls, indicators, and panel meters are as follows:

(1) Voltmeter.

(2) DC ammeter.

(3) Float/equalize switch.

(4) Float adjust control.

(5) Equalize adjust control.

(6) AC input on-off automatic switch.

(7) DC output breakers for fuses.

(8) Panel lights to verify operational condition and to signify a failure.

(9) External relay contacts for remoting alarms.

During normal field testing, it is only necessary to demonstrate the performance of the above-mentioned controls, indicators, and meters. Compliance or noncompliance will be recorded as applicable, on figures 113-1 and 113-2 (USACC Forms 684-R and 685-R).

e. This test may be performed on contractor EF&I systems to verify that they meet specified performance requirements. It may also be used by installer or quality assurance personnel during onsite test activities as directed.

113-2. SPECIFICATIONS.

a. The DC power and distribution system shall operate in accordance with the standard engineering design plan.

b. The AN/FRC-162 and VICOM 4000-2 system shall operate as specified in tables 113-1 and 113-2.

113-3. TEST EQUIPMENT REQUIRED.

a. Variable frequency AC power supply.

b. Variable autotransformer.

c. Load bank.

d. Voltmeter.

e. Ohmmeter.

f. Multimeter.

g. Recorder.

h. Frequency counter.

i. Distortion analyzer.

j. Ammeter.

113-4. TEST PROCEDURES.

a. DC/AC Inverter Subsystem.

(1) *Design verification.*

(a) Connect the test equipment as shown in figure 113-3 and as shown in the equipment instruction manual.

(b) Connect a load bank to the output terminals as shown in figure 113-3. Adjust the load bank to correspond to the full load output as specified for the inverter under test.

(c) Close the input power breaker to inverter 1 and adjust the DC input voltage to -42 VDC. Measure the output voltage from no load to full-rated load. Record the results on figure 113-1 (USACC Form 684-R).

(d) With the frequency counter, measure the output AC frequency of the inverter. The counter should be powered from its internal battery source.

(e) Measure the total harmonic distortion at 120, 180, 240, and 300 Hz. Record the results.

(f) Change the input voltage, in turn, to the parameters listed on figure 113-1 (USACC Form 684-R) and repeat subparagraphs (a) through (e), above. Record the results.

(g) If directed, record the frequency of the inverter output voltage with -42 VDC input for 4 hours. After the initial 4-hour period, adjust the input to -56 VDC and record the frequency for an additional 4 hours.

(2) Field testing.

(a) Connect the inverter output to the distribution system through the protective devices as shown in the equipment instruction manual and engineering package.

(b) Close the input power circuit breaker on inverter 1. Close and open each breaker and observe the panel meters for excessively high or low readings. Open the circuit breaker and repeat subparagraph (a), above, for inverter 2.

(c) Close the input circuit breakers on both inverters. Close the output breakers. The ammeter on one inverter should read the full current as calculated for the applied load at the output voltage. The ammeter on the other inverter should read near zero. Record the voltage and current on figure 113-1 (USACC Form 684-R).

(d) Open the input circuit breaker on the inverter which is carrying the load while observing the output ammeters. The load should immediately transfer to the alternate inverter. Record the results.

(e) Reverse the conditions of the inverters and repeat subparagraph (d), above, for the primary and alternate inverters.

(f) If a load bank is available, repeat subparagraphs (d) and (e), above, at full, three-quarters, one-half, and one-quarter loads, and at no load. Also at each load level, measure the harmonic distortion as outlined in paragraph 113-4a(1)(e), above.

b. Rectifiers. Input power and frequency may be from a commercial source or a local generating system. The input voltage and frequency may vary depending on the rectifier design and facility requirements. The input may also be single or three phase, again depending on the rectifier under test. Typical input frequencies and power that may be encountered are: single phase 120/240 VAC ±10 percent, 47 to 63 Hz; three-phase 208/220/380/416 VAC ±10 percent, 47 to 63 Hz. Before performing the test, verify the input power and frequency requirements of the unit to be tested.

(1) Connect the test equipment as shown in figure 113-4.

(2) Adjust the variable frequency AC power supply output voltage and frequency to correspond to the requirements of the system under test. For example, 120 VAC at 60 Hz will be used as the primary input voltage. Adjust the variable autotransformer for an output of 120 VAC and adjust the load

bank for the calculated load of the equipment to be provided -48 VDC from the rectifiers.

(3) Assuming that the rectifiers are designed for 120 VAC ±10 percent at a frequency of 47 to 63 Hz as shown in table 113-2, adjust the AC input for 108 VAC at 47 Hz. Measure and record the DC output voltage on figure 113-2 (USACC Form 685-R). Adjust the variable AC power supply for 108 VAC at 63 Hz. Measure and record the DC output voltage.

(4) Repeat subparagraph (3), above, at 132 VAC input at frequencies of 47 and 63 Hz. Record the DC output voltage. For the AN/FRC-162 and VICOM 4000-2 system, the output should remain constant at -48 VDC ±1 percent.

(5) Adjust the rectifier AC input to 120 VAC at 60 Hz and turn the float/equalize switch to float. Adjust the float and equalize potentiometers to minimum resistance. Record the DC output voltage.

(6) Adjust the float potentiometer to maximum resistance. Record the DC output voltage.

(7) Set the float potentiometer for a DC output voltage of 2.15 volts per cell (unless otherwise specified). Turn the float/equalize switch to equalize and adjust the equalize potentiometer to maximum resistance. Record the DC output voltage.

(8) Set the equalize potentiometer for a DC output of 2.33 volts per cell (unless otherwise specified) and turn the float/equalize switch to float.

(9) To check the current limit:

(a) Adjust the load bank and rectifier for full load current value as read on the ammeter.

(b) Increase the DC load until the DC output voltage begins to decrease. Record the current limit value. For the AN/FRC-162 and VICOM 4000-2 system, this should occur between 110 and 115 percent of the rated output.

NOTE: The procedures in subparagraphs (1) through (9), above, may or may not be required during field testing since they can also be considered as design verification tests.

c. Parallel Operation. This portion of the procedure will verify that the two rectifiers operate in parallel and that the failure of one unit will not result in traffic outage.

(1) Adjust the AC input to 120 VAC at 60 Hz.

(2) Adjust the equalize potentiometers until the load is shared equally by both rectifiers. On the AN/FRC-162 and VICOM 4000-2 system, the internal load sharing circuits allow for each rectifier to share the load (DC current) within 10 percent of each other. Record the results on figure 113-2 (USACC Form 685-R).

(3) Switch rectifier 1 off; rectifier 2 should assume the full load. Switch rectifier 1 on; the load should be shared equally by both rectifiers. Switch rectifier 2 off; rectifier 1 should assume the full load. Switch rectifier 2 on; the load should be equally shared by both rectifiers. Record the results.

(4) With the oscilloscope, measure the noise level (ripple) at the output of each rectifier. Measure the level with both rectifiers operating in parallel, rectifier 1 on and rectifier 2 off; and again with rectifier 2 on and rectifier 1 off. Record the results. For the AN/FRC-162 and VICOM 4000-2 system, the ripple should be less than 100 mV.

d. Cold Standby Operation.

(1) Adjust the front panel controls of the rectifiers to place rectifier 1 on-line and rectifier 2 on cold standby. Switch rectifier 1 off; rectifier 2 (standby) should automatically switch on and assume the full load.

(2) Place rectifier 1 on cold standby and rectifier 2 on-line. Switch rectifier 2 off; rectifier 1 should automatically come on-line and assume the full load.

(3) Place both rectifiers on-line and equalize the load if required.

(4) Record the results on figure 113-2 (USACC Form 685-R).

e. Alarms.

(1) Connect the test equipment as shown in figure 113-4. Adjust the AC input to 120 VAC at 60 Hz. Refer to the technical manual or manufacturer's literature for the equipment under test.

(2) Adjust the rectifiers' low voltage alarm for -46 VDC and the high voltage alarm for -52 VDC or as specified for the equipment under test.

(3) Switch rectifier 2 off and slowly decrease the output voltage of rectifier 1 until the low voltage alarm indicator illuminates. With the ohmmeter across the external (dry) relay contacts of the low voltage alarm circuit, continuity should be indicated. Slowly increase the output voltage of rectifier 1 until the alarm indicator lamp extinguishes. The ohmmeter should indicate an open circuit.

(4) Continue to increase the output voltage until the high voltage alarm indicator illuminates. The ohmmeter should indicate continuity. Set the output voltage of rectifier 1 to -48 VDC. The alarm lamp should extinguish and the ohmmeter should show an open circuit.

(5) Repeat subparagraphs (2) through (4), above, with rectifier 2 on and rectifier 1 off.

(6) Switch both rectifiers on. On rectifier 1, turn the AC on/off switch off. The AC failure lamp for rectifier 1 should illuminate and the ohmmeter should indicate continuity at the external alarm contacts.

(7) Place rectifier 1 back on-line and repeat subparagraph (6), above, with rectifier 2 off.

(8) Place both rectifiers back on-line. Switch the DC output circuit breaker for rectifier 1 off. The no output/charge indicator lamp for rectifier 1 should illuminate and continuity should be observed on the ohmmeter. Switch the DC circuit breaker on; the lamp should extinguish and the ohmmeter should show an open. Repeat these procedures for rectifier 2. Record the results on figure 113-2 (USACC Form 685-R).

(9) In turn, insert a defective fuse into each fused output of the -48 VDC power and distribution system. For each output tested, the fuse alarm lamp should illuminate and the ohmmeter should show continuity at the alarm contacts. Record the results.

113-5. DATA RECORDING AND ANALYSIS.

a. Review the recorded data for accuracy, completeness, and compliance with specified requirements. Summarize the test results on figure 3-7 (DD Form 2091).

b. Remove all test equipment and restore the system to its normal configuration.

c. If the system fails to meet specified requirements, notify the responsible activity of required corrective actions.

DC/AC INVERTER POWER SUBSYSTEM (CCR 702-1-3)			PAGE OF PAGES
DATA SHEET			DATE (DAY, MO, YEAR)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGR SIGNATURE
EQUIPMENT TYPE & MFR		CALCULATED AC LOAD VAC AMPS	CALCULATED DC LOAD VDC AMPS
DC INPUT LEVEL (DESIGN)		AC OUTPUT VOLTS (DESIGN)	AC OUTPUT AMPS (DESIGN)
SER NO. _____		INVERTER ○ 1 ○ 2	

PARAMETER	OUTPUT VOLTAGE (VAC)	RATED LOAD (AMPS)	MEAS FULL LOAD (AMPS/Hz)	HARMONIC DISTORTION (%) 120 Hz	180 Hz	240 Hz	300 Hz
VDC INPUT							
-42							
-44							
-46							
-48							
-50							
-52							
-54							
-56							

FREQUENCY STABILITY	4 HRS % AT FULL LOAD		8 HRS % AT FULL LOAD	
CURRENT LIMITING	VOLTS		% OVERLOAD	
CIRCUIT PROTECTION	INPUT YES NO		OUTPUT YES NO	
TRANSFER	% CYCLE		msec	

ALARMS & LAMPS	C	NC	ALARMS & LAMPS	C	NC
VISUAL			EACH LOAD		
EXTERNAL REMOTE			BYPASS (MNL-AUTO)		
REVERSE POLARITY			SWITCHING		
INPUT/OUTPUT FAILURE					

USACC FORM 684-R
1 MAY 79

Figure 113-1. DC/AC inverter power subsystem data sheet.

CCP 702-11

RECTIFIER–CHARGER POWER SUBSYSTEM (CCR 702-1-3) DATA SHEET			PAGE OF PAGES DATE (Day, Mo, Year)
LINK NO.	LOCAL STATION	DISTANT STATION	TEST ENGINEER
EQUIPMENT TYPE & MFR		CALCULATED AC LOAD VAC AMPS	CALCULATED DC LOAD VDC AMPS
DESIGN AC INPUT VAC AMPS		TESTED AT VAC/AMPS VAC AMPS	DESIGN DC OUTPUT VDC AMPS

PARAMETER	AC INPUT (VAC)	INPUT FREQ (Hz)	DC OUTPUT (VDC)	DC OUTPUT (AMPS)
10% BELOW DESIGN INPUT		LOW Hz		
10% BELOW DESIGN INPUT		HIGH Hz		
10% ABOVE DESIGN INPUT		HIGH Hz		
10% ABOVE DESIGN INPUT		LOW Hz		
FLOAT & EQUALIZE MAX RESISTANCE				
FLOAT TO MAX RESISTANCE				
FLOAT FOR 2.15 VOLTS PER CELL				
CURRENT LIMIT % OF DESIGN				%

CHARGING RATE	%	90% FULLY CHARGED	HOURS
REGULATION FULL LOAD	%	HALF LOAD	%
			mV
LOAD SHARING % IN PARALLEL			%
AUDIO NOISE (RIPPLE)			mV
PARALLEL OPERATION	C ☐	NC ☐	
COLD STANDBY OPERATION	C ☐	NC ☐	
ALARMS LOW VOLTAGE ACTIVATES AT VDC		HIGH VOLTAGE ACTIVATES AT	VDC

	C	NC
AC FAILURE		
NO OUTPUT CHARGE		
WARNING LIGHTS		
HIGH-LOW DC ALARM		
LOCAL		
REMOTE		
PANEL METERS		

COMMENTS

USACC FORM 685-R
1 MAY 79

Figure 113-2. Rectifier-charger power subsystem data sheet.

Table 113-1. Technical Characteristics of DC/AC Inverter Used in the AN/FRC-162 and VICOM 4000-2 System

PARAMETER	SPECIFICATION
Input voltage	-42 to -56 VDC from a -48 VDC source.
Inverter output and regulation	120 VAC single phase ±4% from no load to full load with a power factor of 0.75 to 1.0 lag over the temperature range of 0° to 40°C.
Output frequency	60 Hz ±2% from zero to full load.
Frequency stability	±1%.
Harmonic distortion	5% maximum at all loads.
Efficiency	75% minimum at 50 VDC input, unity power factor.
Transients	65 VPP for maximum duration of 2 minutes.
Capacity	1 to 10 kVA depending on unit and site.
Circuit protection	1) DC input breaker (manually operated) fuse to protect internal control circuit. 2) DC output breaker 5-amp automatic current limiting.
Solid state transfer switch (SSTS)	Transfer from one inverter to the standby unit in 1/4 cycle at 60 Hz.
Bypass switch	Commercial or auxiliary power.
Alarms and status lights	1) Visual and external relay contacts (dry): a) Reverse polarity. b) Input/output failure SSTS. 2) Red light for each load.
Ripple content	Not to exceed 100 mV RMS.

Table 113-2. Technical Characteristics of DC Power, Rectifiers, and Chargers Used in the AN/FRC-162 and VICOM 4000-2 System

PARAMETER	SPECIFICATION
Input power	120/240 VAC ±10%, 47 to 63 Hz, single-phase; 208/220/240/380/416 VAC ±10%, 47 to 63 Hz, three-phase.
Battery charging current capacity	Automatically controlled by the rectifier. The capacity of each rectifier unit shall be sufficient to restore the battery supply to 90% fully charged condition from a fully discharged condition within 16 hours while providing the full DC operational load.
Charging rate	Minimum of 25% of the average hourly discharge rate for the uninterruptible supply.
DC power output tolerances and regulation	±1% from 0 to 100% of rectifier capacity with AC input steady state and transient variations of ±10%; maintain float charge of 2.15 volts per cell and equalizing charge of 2.33 volts per cell.
Efficiency and power factor	Full load efficiency shall not be less than 80% power factor at full load of not less than 0.80.
Hash and electrical noise current limit	Less than 30 mV, adjustable from 70 to 100% of rectifier rated output.
Load sharing	DC current within 10% of each unit in parallel.
Mode of operation	Parallel, load sharing.
Audio noise (ripple)	Less than 100 mV RMS.

Table 113-2. Technical Characteristics of DC Power, Rectifiers, and Chargers Used in the AN/FRC-162 and VICOM 4000-2 System (continued)

PARAMETER	SPECIFICATION
Controls and alarms	1) DC voltmeter. 2) DC ammeter. 3) Float/equalizer switch. 4) Float adjust rheostat. 5) Equalize adjust rheostat. 6) DC circuit on-off-auto switch. 7) DC circuit breakers. 8) Status panel lights (DC fail and no output/charge). 9) DC ground. 10) Relays with dry contacts for remote and local and alarm functions. 11) Warning lights (red). 12) Abnormal battery charge rate and HI-LO DC alarm (local and remote).
Battery power	Capable of supplying power for the complete technical load for 4 hours minimum at manned sites and 8 hours minimum at unmanned sites.
Battery type	Float service with expected 20-year service life (Federal Specification W-B124B, Class 2, Style A).

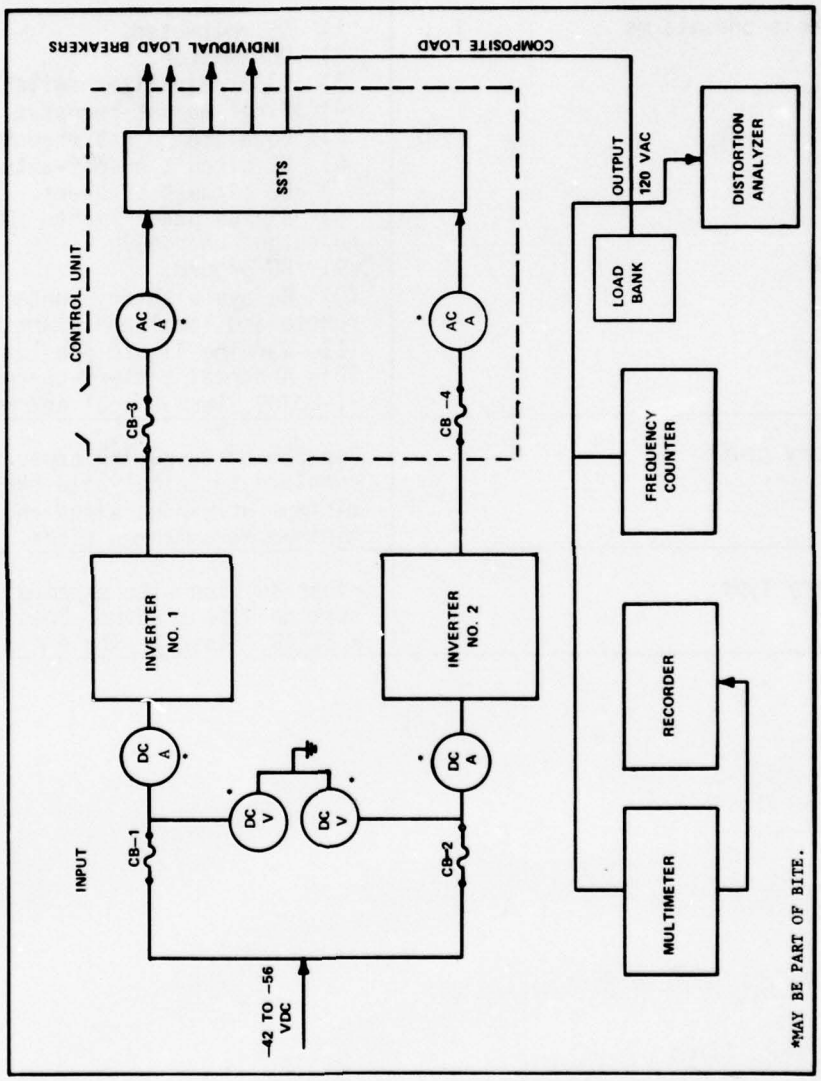


Figure 113-3. DC/AC inverter test setup.

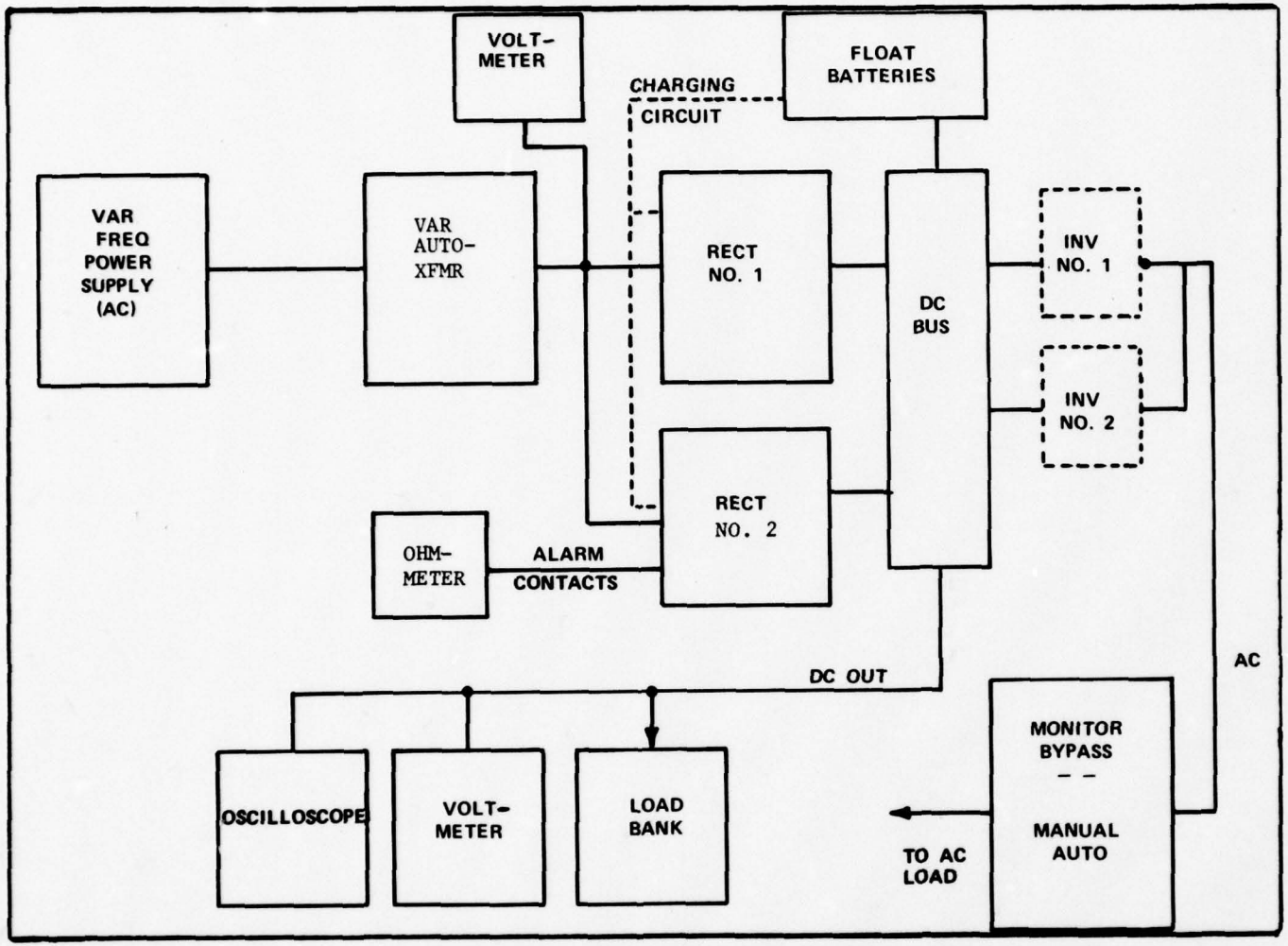


Figure 113-4. DC power system test setup.

CHAPTER 114

MULTIPLE PARAMETER DATA RECORDING (DT-311)

114-1. GENERAL.

a. The purpose of this test is to provide the techniques for recording time-varying parameters of the digital radio link/system. The condition of the link can then be determined through analysis of the recorded data.

b. Before performing this test, the individual parameters should be verified as meeting the established standards as outlined in previous chapters.

c. The efficiency of a digital link depends on proper operation of the radio, multiplexers, and the voice processing equipment. In this test, the most important parameters should be recorded, the data analyzed, and the results compared to established standards. Assuming that the individual test sequences as contained in previous chapters are performed and the results are within specifications, the data from this test will provide a baseline of key performance characteristics on a link basis.

d. The minimum recording period according to DCAC 310-70-57 is at least 3 days after all adjustments and alinements have been accomplished. The length of time, if different from the DCA requirement, will be as directed by the team chief or onsite NCOIC.

e. The recording equipment may consist of:

(1) A six or more channel analog paper tape recording device.

(2) Digital recorders and printers for parameters such as BER, block errors, and loss of synchronization.

(3) Event markers or recorders to signify switching, number of alarm activations, or other significant events.

(4) On-line automated calculators, interface devices, printers, and X-Y recorders.

f. Parameters that can be recorded on a digital link/equipment are numerous; however, only those that provide a primary indication of link performance should be selected. A partial list of recordable parameters for the digital multiplex and fully digitized radio is shown below.

(1) Timing frequency stability.

(2) Timing jitter.

(3) Received signal level.

(4) BER at the channel output port of the 1st and 2d level multiplexers as well as at the MBS and SCBS of the radio.

(5) Signal-to-noise quantizing.

(6) Idle channel noise.

(7) Impulse noise at the voice frequency channel level.

(8) Test tone stability.

(9) Bit count integrity.

(10) Carrier group alarm and other significant alarms such as loss of frame or synchronization.

(11) High and low frequency jitter on the timing and MBS or at the channel level.

g. The parameters to be recorded are normally specified in the DCA requirements for DCS links. If not, minimum requirements are as follows:

(1) RSL for all receivers.

(2) BER at 1.544 mb/s and if equipment is available, at the 12.928 mb/s or the digital channel output.

(3) Signal-to-noise quantizing.

h. Before, during, and after the recording period, mark the stripchart with at least the following information:

(1) Recording site, distant station, data and time (Zulu), and run number.

(2) Link number if applicable.

(3) Recorder channel number and parameter being recorded on each channel.

(4) 2d level multiplex port number, 1st level multiplex voice, or data channel number used for recording the data.

(5) Calibration information for all recording channels.

(6) Chart speed, including all changes during the test. The suggested chart speeds are as follows:

CHART SPEED	TEST TIME
Fast (1 to 5 mm/sec or whatever speed is required for proper delineation	Initial test run of 5 minutes after calibration and start of of test

CHART SPEED	TEST TIME
Slow (10 to 50 mm/min)	30-minute intervals
Fast (1 to 5 mm/sec)	5-minute intervals or whenever unusual data is observed
25 mm/min (tropospheric) 5 mm/min (LOS)	Final 3-day recording
Optional speed	As required for special investigation of any recorded parameter

i. On some systems, variable resistive capacitance (RC) time constants may be required to smooth the data so that a median value can be derived on rapid time changing parameters. The switchable time constants may provide 0.001, 0.01, 0.5, 1.0, 5.0, and 10.0 seconds for controlled smoothing, and if used, they must be placed between the output of the recorder logarithmic amplifiers and the recorder channel input. The use of these networks will allow data recording flexibility and will provide smoothed data graphs to facilitate review and analysis of the test data. Normally, on digital LOS links, smoothing should not be necessary.

j. On the data sheets, enter all station link data, test run numbers, chart speeds, run time periods, and channels being recorded. Calibrate each channel of the recorder before and after the daily recording period. For ease in scaling the recordings, at the beginning of the stripchart, make a duplicate set of calibrations from a section of the recording chart paper. When calibrating the recorder channels, select the midscale (center of chart), end-scale (edge of chart), and sensitivity values that are suitable for the quiescent value and dynamic range of the parameter being recorded. Improper selection of these settings could result in off-scale recordings. Note any significant event that affects the parameters being recorded, and the time and point of occurrence on the chart recording.

k. Manual data reduction techniques of paper stripchart recordings require only a reasonable amount of work and should be accomplished while the test is in progress. This procedure will yield radio-link performance during the time the tests are being conducted. The use of an on-line automated system would yield real time complete data recording and reduction thereby providing rapid onsite analysis of performance, including time correlation.

114-2. SPECIFICATIONS. The digital radio link/system shall operate as specified in the appropriate chapter for the individual parameter being tested.

114-3. TEST EQUIPMENT REQUIRED.

a. Multichannel recorder.

b. Logarithmic/linear amplifier.

c. Audio frequency noise source.

d. Noise measuring set.

e. Audio frequency counter.

f. Transmission measuring set.

g. 70-MHz logarithmic/linear amplifier-detector.

h. True RMS voltmeter.

i. RF counter.

j. Impulse noise test set.

k. Audio phase jitter meter.

l. Phase jitter meter (NRZ/bipolar).

m. Jitter generator.

n. Digital voltmeter.

o. Oscilloscope.

p. BER test set (low speed).

q. BER test set (high speed).

r. Digital printer.

s. RF power meter.

t. RF sweep generator.

u. RF voltmeter.

v. Attenuators, as required.

w. 1020-Hz notch filter.

x. 20-Hz low-pass filter.

y. 3.1-kHz weighting filter.

114-4. TEST PROCEDURES.

a. General.

(1) Connect the test equipment as shown on the applicable test setup and allow approximately 30 minutes for warmup and stabilization.

(2) Perform the voice channel test tone stability (net loss), idle channel noise, S/Nq, data error rate, etc. at the circuit patch bay unless otherwise directed.

(3) Locate the recorder to minimize the length of unbalanced test leads. Most of the unbalanced test points will be associated with the radio. However, depending on strapping options selected, unbalanced test points may also be encountered at the multiplex equipment and in the TCF. Regardless of the configuration, connections to the equipment under test and to the test equipment must observe proper grounding and shielding techniques. This will avoid ground loops that could provide erroneous recordings as well as affect the instrumentation. For additional information on grounding, bonding, and shielding, refer to MIL-STD-188-124.

NOTE: All of the recorded parameters listed in subsequent paragraphs may not be required on a digital link/system. They have been included in this procedure to cover any requirement that might occur.

b. Test Tone Signal Level Stability.

(1) Establish the test tone signal level stability channel recording in accordance with the detailed test setup and calibration shown in figure 86-1.

(2) At the transmit end, insert a 1020-Hz test tone into TP-2 at a -15 dBm0 level. Adjust the level of this tone at point A (fig. 86-1) to -15 dBm0 (-15 dBm). Measure and record this test tone signal level on figure 86-3 (DCA Form (Test) T1-2).

(3) At the receive end, disconnect the multiplex voice channel from point A and connect the generator (transmission measuring set) to point A.

(4) Using a 1020-Hz test tone signal from the transmission measuring set, calibrate the recorder chart in 1-dB steps over a range of ±5 dB centered at -15 dBm0. Disconnect the transmission measuring set after the recorder channel has been calibrated. Reconnect the recorder channel input to the multiplex channel at point A.

(5) During the recording, periodically monitor the received tone level with the transmission measuring set and the test tone frequency with the frequency counter. At the transmit end, monitor the input tone level and frequency. The receive end must be informed of any changes in the input tone signal at the transmit end so that a suitable notation can be entered on the stripchart.

NOTE: If the equipment under test is not carrying operational traffic, a test tone level of 0 dBmO may be used.

c. Idle Channel Noise.

(1) Establish the idle channel noise test setup as shown in figure 114-1.

(2) Select a voice frequency channel that is likely to be affected by crosstalk from the 1020-Hz test tone used in paragraph 114-4b. Refer to table 70-1 for those channels that might experience crosstalk from the test tone stability recording.

NOTE: This test is normally performed between the circuit patch bay at the receive and transmit ends. However, it may be performed at the VFPB, at the equipment, or at any other accessible test point.

(3) At the transmit end, insert a 1020-Hz test tone signal into the circuit patch bay at -10 dBmO for operational systems and 0 dBmO for nonoperational systems. Adjust the level of this tone to 0 dBmO or -10 dBmO, as applicable, at point B (fig. 114-1). Record the test tone level on figure 114-2 (DCA Form (Test) T1-3).

NOTES: 1. This test tone signal reference check must be made periodically during the test.

2. On figure 114-2 (DCA Form (Test) T1-3), change the SG and G columns to read 2D LVL MUX and 1st LVL MUX, respectively. Also change the voice channel noise equation to read MEDIAN S_T/N dB = S_m - N - S_T with units of measure to be (dBm) (dBmO) (dBm).

(4) Remove the test tone at the transmit end and terminate the channel input into its characteristic impedance.

(5) At the receive end, connect the terminated noise measuring set to point B (fig. 114-1) and measure the average level of idle channel noise (in dB) for 3.1-kHz flat and C-message weighting. Record these noise power levels. If the flat weighting measurements are more than 2 to 3 dB greater than the C-message measurements, examine the noise spectrum at the output of the 3.1-kHz flat weighted filter for noise components below 300 Hz. Also, with a wave analyzer, examine the spectrum above the voice frequency channel range for unwanted harmonics or other signals. If the noise components below 300 Hz account for the 2- to 3-dB difference in the measured levels, the idle channel noise may have to be recorded using C-message weighting only. This determination will be made by the team chief or onsite NCOIC.

(6) Disconnect the multiplex voice frequency channel output (receive end) from point B. Using the audio noise generator, establish a noise level recording equal to the value measured in subparagraph (5), above, at the input terminals of the noise measuring set.

(7) Adjust the recorder and logarithmic amplifier to indicate 10 percent of full scale for the average noise power measured in subparagraph (5), above.

(8) Adjust the amplifier for a 10-dB, full-scale response using the procedures supplied with the recording equipment. If wider variations are noted during subparagraph (5), above, a larger full-scale value will be selected.

(9) Using the noise power levels indicated on the noise measuring set for 3.1-kHz flat weighting, vary the audio noise generator output level and calibrate/aline the stripchart in 2-dB steps over the 10-dB range. Mark the recorder channel chart calibration in dBm and dBm0, using a -10 dBm0 test tone signal to establish the 0-dBm0 deflection on the chart recorder.

(10) Disconnect the noise measuring set from the particular voice channel filter being used and reconnect the recorder input to point B on figure 114-1. During the recording, periodically monitor the noise measuring set dBm readings at point B. Compare the measured values with the actual stripchart to verify the recorder calibration. If required, plot the idle channel noise versus RSL on figure 29-5 (DCA Form (Test) T1-14).

d. Impulse Noise.

(1) On some recorders, event markers are available on the edges of the stripchart to record the number of events. If this option is available, the impulse noise can be recorded and correlated with the idle channel noise recording. However, during a noise burst, the number of events cannot be distinguished on the chart recording.

(2) If impulse noise recordings are required, initially set the impulse noise counters to 72, 62, and 52 dBrnC0 (C-message). Ensure that the TLP is considered in setting the individual counter levels. For example, if the TLP is 0 dBm0, set the counters at 72, 62, and 52 dBrnC0, respectively. Record the counter settings and the receive TLP on figure 114-2 (DCA Form (Test) T1-3). If all counters run continuously at this level, adjust all counters in 10-dBrnC0 steps until the least sensitive counter runs only occasionally. Record the settings on figure 114-2 (DCA Form (Test) T1-3).

(3) During the recording corresponding to the run period of the idle channel noise recording, record the total number of impulse noise counts on figure 114-2 (DCA Form (Test) T1-3). Ensure that the counters do not exceed their capacity and recycle.

e. Voice Frequency Channel Phase Jitter.

(1) Establish the test setup shown in figure 114-3.

(2) Disconnect the phase jitter meter input from point A. Calibrate the channel of the stripchart recorder over a range of ±20 degrees by using the jitter generator or the phase jitter meter as the calibrating standard. Set

the phase jitter meter to 1020 Hz for voice frequency channel measurements and to 600-ohm balanced impedance. Once the chart recorder has been calibrated over the required range in 2-degree steps, reconnect the phase jitter meter to the voice frequency channel output (point A on fig. 114-3).

(3) Reduce the time varying charcteristics of the spurious phase variations recorded on the stripchart. Record this data on figure 114-4 (DCA Form (Test) T1-4).

NOTE: On figure 114-4 (DCA Form (Test) T1-4), change the terminal radio equipment block to read BIT RATE. Also change the SG and G columns to read 2D LVL MUX PORT OR BB and 1ST LVL MUX GP respectively.

f. Phase Jitter and Phase Hits at the Digital Outputs. The phase jitter measurements and recording can be performed at the digital output of the radio, at the 2d level multiplex port, or at the digital channel output of the 1st level multiplexer (point A on fig. 114-3).

(1) Establish the test setup shown in figure 114-3 with the phase jitter meter connected to the MBS output of the radio or at the multiplex channel or ports as directed.

(2) Configure the phase jitter meter for the data rate at which the measurements are to be made. Observe the input impedance, level, and signal format.

(3) Calibrate the chart recorder to cover ±20 degrees, using the jitter generator as outlined in paragraph 114-4e. Once the calibration sequence has been completed, connect the phase jitter meter input to the digital channel, port, or MBS as required.

(4) Record the peak jitter on figure 114-4 (DCA Form (Test) T1-4) for each run period. The run period will be 15 minutes unless otherwise specified.

(5) Some time during the recording sequence, switch the low frequecy weighting from 10 Hz to 10 kHz and observe any change in the recorded jitter level. Periodically change the weighting network and annotate the stripchart for each change.

(6) Set the phase jitter meter timer for 15 minutes and initially set the hit threshold level for X2. This setting represents 2 times the full-scale reading of the meter. If the internal counter runs continuously, change the threshold until only an occasional count is observed on the meter. At 15-minute intervals, record the total number of counts and levels on figure 114-4 (DCA Form (Test) T1-4). Also record the information on the recorder channel being used for recording the phase jitter.

(7) Follow the procedures in subparagraphs (1) through (6), above, for recording timing jitter and hits. Record the data on figure 114-4 (DCA Form (Test) T1-4) and identify the recorded parameter.

g. Signal-to-Noise Quantizing.

(1) Establish the test setup shown in figure 114-5. The recording of S/Nq may be made at the various points shown in the figure; however, for end-to-end system performance, the measurement will be made at the circuit patch bay.

(2) At the transmit end, adjust the oscillator output for -10 dBm0 at a frequency of 1020 Hz as read on the frequency counter.

(3) At the receive end, measure and record the test tone level in dBm to ensure that subsequent noise level recordings are valid. If the channel input and output levels are not within specifications (±1 dB), they will be adjusted before proceeding with the test. Perform the measurement with the notch filter in and repeat the measurement with the filter out. Also, perform the noise measurement with the notch filter in for 3-kHz flat and C-message weighting. Record the results on figure 114-2 (DCA Form (Test) T1-3).

(4) At the receive end, disconnect the slot noise test set from the multiplex channel and connect the audio noise test set to the slot noise test set. Using the measured value from subparagraph (3), above, determine the appropriate range over which the recorder should be calibrated. Adjust the noise generator output to the noise equivalent measured in subparagraph (3), above, and center the chart pen for midscale deflection. Adjust the noise generator output in 1- or 5-dB steps to provide a plus and minus calibration for the left- and right-hand edges of the chart paper, respectively.

NOTE: If the link is stable and the noise has only minor variations, 1-dB steps ±10 dB of center may be adequate.

(5) Disconnect the audio noise generator from the slot noise test set and connect the slot noise test set input to point G on figure 114-5 unless otherwise specified.

(6) At the transmit end, insert the -10 dBm0, 1020-Hz test tone into the circuit patch bay. At the receive end, adjust the slot noise test set notch filter to produce a minimum reading on the slot noise test set meter. If a slot noise test set with a tunable filter is not available, a fixed 1020-Hz filter can be used by having the transmit end slowly adjust the oscillator frequency until the tone is nulled out at the receive end.

(7) At the transmit end, connect a second test oscillator to the channel that will most likely interfere with the channel being recorded (table 70-1). Adjust the test tone for 1020 Hz at 0 dBm0, and at the receive end, observe the slot noise test set to verify that the noise level does not change. If a change is noted, record the S/Nq with the tone applied at the transmit end.

(8) Periodically monitor the noise level variations with the slot noise test set to verify recorder calibration.

(9) Record all data on figure 114-2 (DCA Form (Test) T1-3), changing the data sheet as required to accommodate the recorded results. Plot the S/Nq versus RSL on figure 29-5 (DCA Form (Test) T1-14).

h. Bit Error Rate.

(1) *General.*

(a) The primary purpose of this recording is to determine whether or not the digital radio and multiplex are operating in an optimum condition. Therefore, an analysis of the link digital error characteristics is the best method for determinig the overall performance of a digital link. If the link performs within RSL specifications, the digital radio and multiplex can be considered satisfactory.

(b) The average BER per run is defined as the number of bit errors measured during the run interval divided by the total number of bits transmitted during the run. The average BER is related to the median RSL, and in order to obtain a range of RSL's, an artificial variation of the RSL must be produced by varying the RSL.

(c) To enable further analysis of BER distributions, the BER test set will be used in conjunction with a digital recorder. This recorder will provide a paper tape record of time, random error, bursts of errors as well as loss of clock, loss of synchronization, and data overflow. Another method that may be used for the recording is shown in figure 114-6. The calculator will provide a printout of the long- and short-term medians of the BER versus RSL if programed properly.

(d) On the TD-1192 (AN/FCC-98) and TD-1193 multiplexers, the BER test set may be connected to the data channel input or at any selected port as long as the levels signal format and data rate are compatible with the selected test point. On the CY-104 and AN/FCC-97, if data is to be inserted into the channel at the circuit patch bay, use a separate data MODEM to interface the BER test set with a voice frequency channel.

(e) Before performing the BER recording test, the receiver small signal performance test (DT-226) will be performed to establish the BER threshold.

(2) *Specific.*

(a) Establish the test setup as shown in figure 114-6.

(b) At the transmit and receive ends, set the BER test set to correspond to the data rate, signal format, and impedance of the test point at which the test is being performed.

NOTE: If the BER test set input/output impedance does not match the equipment test point (balanced or unbalanced), use an interface device between the BER test set and the test point. For instance, if inserting the BER test set into the aggregate bit stream input (bipolar option), the BER test set will be set for 100 ohms (balanced).

(c) At the transmit and receive ends, measure the peak-to-peak voltage at the test points shown in figure 114-6. Record these levels on figure 89-3 (USACC Form 666-R).

(d) At the receive end, record the RSL as previously determined from the calibrated AGC curve.

(e) At the transmit end, send data for 1 minute and verify the number of errors at the receive end. If no errors occur at the operating RSL, inject a known amount of errors at the transmit end by pressing the error inject switch of the BER test set. At the receive end, verify that the received errors correspond to the number of errors transmitted.

(f) At the receive and transmit ends, reset the BER test set counters to zero, initiate send data, and continue sending data for the period specified.

(g) For each run period, record the number of received errors on figure 89-3 (USACC Form 666-R).

(h) If testing the digital radio at the MBS or SCBS input/output or if a plot of BER versus RSL of a link is required, insert an attenuator in the receive side of the link as shown in figure 114-5. On stable links where there is very little variation of the RSL with time, an artificial variation of the RSL can be accomplished by alternating the RSL.

(i) At the receive end, adjust the attenuator to provide the desired RSL. This may be at $5x10^{-9}$, $5x10^{-2}$, or some other established BER level. For the AN/FRC-( ), the nominal RSL for these error rates is contained in tables 29-4 and 29-5. For the AN/FRC-162 and VICOM 4000-2 system, adjust the RSL to -71 dBm which should equate to a BER of $1x10^{-7}$.

(j) Transmit data for the specified period at the selected RSL's and record the test results for each run on figure 89-3 (USACC Form 666-R).

(k) Plot the BER versus RSL on figure 29-4 (DD Form 2099), using the data from figure 29-3 (DD Form 2098).

i. Received Signal Level.

(1) Connect the test equipment as shown in figure 114-7. The polarity reversal amplifiers shown in this figure may or may not be required, depending on the recorder being used. The DC logarithmic/linear amplifiers shown in the figure may also be a part of the recorder plug-in modules. The 20-Hz low-pass filter shown in the figure is used to preclude low frequency components from affecting the recorded data through pen jitter.

(2) Connect the RF sweep generator output through a 10-dB attenuator, and with the frequency counter, adjust the generator frequency to the assigned center frequency of the receiver. Connect the RF power meter to the generator output as shown in the calibration setup and adjust the generator output power to the predicted RF signal level, considering the 10-dB attenuator.

(3) Verify that the power meter reading corresponds to that indicated on the generator output meter and step attenuator. Reduce the generator output in 1-dB steps from the predicted RSL until the signal is at least 10 dB below the predicted value. Observe that for each 1-dB step the generator output

corresponds to the power meter reading. Repeat this procedure for a generator output at least 10 dB above the predicted RSL. If there is a difference between the generator output indications and the power meter readings, establish the receiver input power level at each calibration step with the power meter.

(4) Connect the RF sweep generator to the receiver RF input at the RF interface point. Adjust the generator output for the predicted RSL as read on the digital or RF voltmeter. The level of the AGC DC voltage or IF signal may be determined from the receiver quieting versus RSL graph (fig. 27-4). Adjust the logarithmic/linear amplifier and recorder to position the recorder pen at the center of the chart paper.

(5) Increase the RF sweep generator output in 1-dB steps, and adjust the recorder and logarithmic/linear amplifier controls over a range that will include the full dynamic range of the expected RSL variations. Generally, a range of 20 dB full scale is adequate for most LOS systems while a larger range is required on tropospheric or deep fading LOS links.

(6) Calibrate the radio receiver in terms of the RF signal power versus the DC voltage (point B on fig. 114-7). The absolute value of this DC voltage will depend upon whether an AGC or logarithmic/linear amplifier-detector is used. Plot the AGC or IF voltage on figure 3-4 (DD Form 2094). Simultaneously, calibrate the recorder channel by marking each deflection of the recorder pen with the corresponding RF signal power level at the input terminal of the radio receiver.

(7) Plot the individual run-medians from the chart recording on figure 29-5 (DCA Form (Test) T1-14), using the data entered on figure 114-8 (DCA Form (Test) T2-2).

j. Other Recorded Parameters. Additional parameters that may be recorded in conjunction with those listed in paragraph 114-1f are shown in figure 114-9. These parameters may be recorded by use of a digital printer, event recorder, programmable calculator, or a stripchart.

114-5. DATA RECORDING AND ANALYSIS. The data reduction techniques outlined in this paragraph will be used to determine the measured performance compared to the calculated performance. All the recorded data will be reduced and plotted as indicated in succeeding paragraphs. The significant measured performance parameters will be plotted on the graph at the end of each run to obtain a real time measure of the radio link performance and to establish the onsite level of performance.

a. Test Runs.

(1) The stripchart recordings will be divided and numbered in time intervals or runs; the duration of these runs will be approximately 5 to 15 minutes each. The median value is defined as that level at which the curve or recording spends equal time above and below the established reference.

(2) For each of the recorded signals, use a recording time constant which is small enough and a chart speed which is fast enough to delineate the signal

so as to show the short-term variations. The short-term period is defined as being of short duration relative to the duration of a run.

b. Amplitude Probability Distribution.

(1) Amplitude probability distributions for each run will be measured in terms of short-term variations of the chart recordings. The short-term variation is defined as a time interval less than the duration of a run.

(2) The amplitude probability distributions of chart recordings will be obtained by manually scaling over the amount of time that the curve is above particular (scaling) levels. Determine the percentage of time that the curve is above a particular scaling level and plot the data on probability paper in terms of percentage of time ordinate values are exceeded versus (scaling) levels. This plot will be the amplitude probability distribution of the scaled chart recording, and it will also give the median value of the distribution.

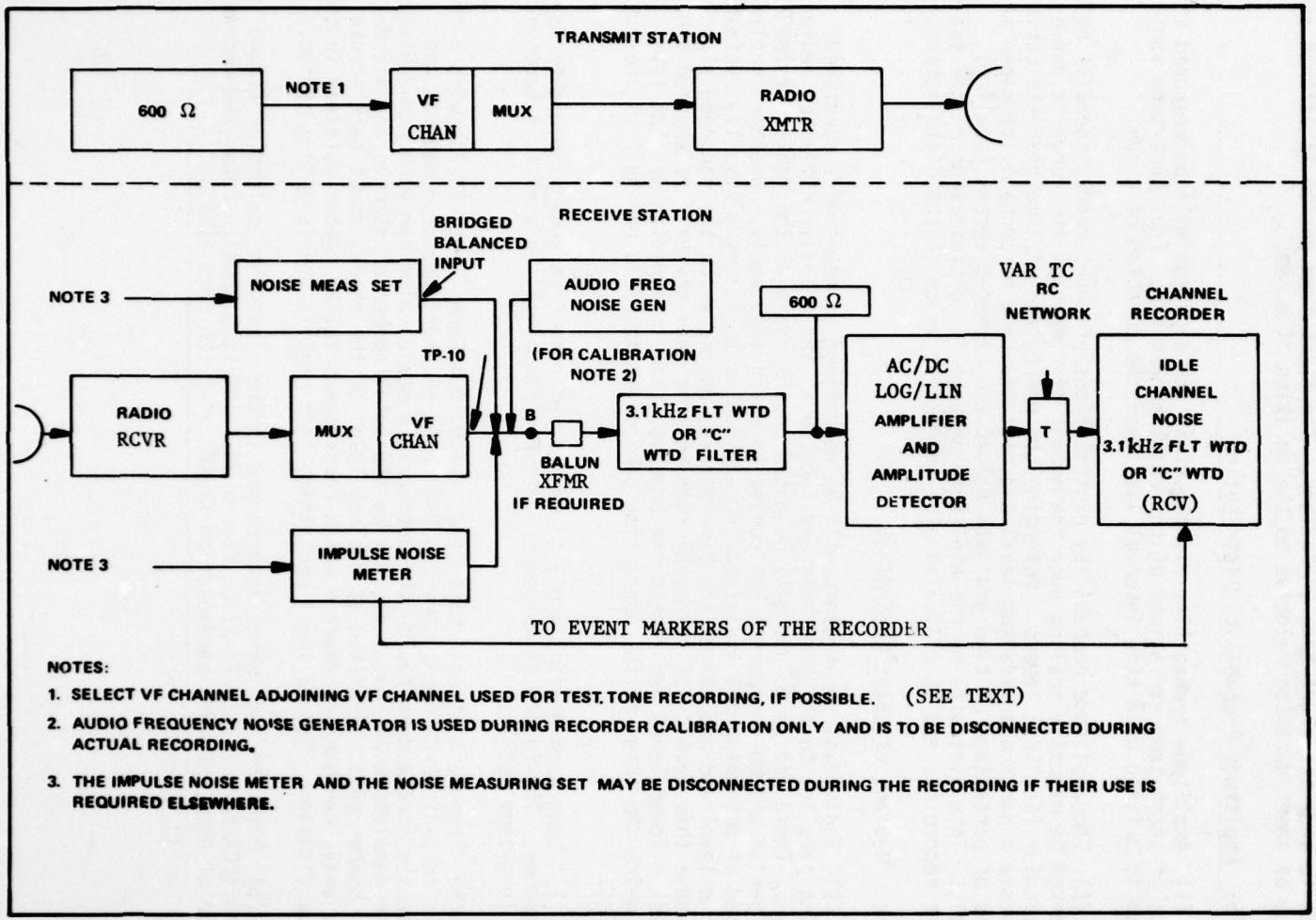
c. Medians of Chart Recordings.

(1) Individual run-medians will be determined by means of a stretched string parallel to the time axis and located at the visually estimated median level. These median values will be noted on the chart at the center of the run period and on the particular curves to which they apply. Another (scaling) method of determing the individual run-median is to select a visually estimated median level and add all of the time periods during which the recorded signal is above this level. If the total time is less than one-half of the run time, select a lower level and repeat the process. The true median is that level for which the total of the added time periods is equal to one-half of the run period.

(2) Long-term medians apply to periods of time from several hours to days or months. The following method of data reduction will be used to determine the long-term median.

(a) Prepare a stroke chart (fig. 114-8 (DCA Form (Test) T2-2)) with a dB scale in 1- to 2-dB steps covering the range of chart-measured medians and place the stroke mark beside the appropriate scale value for each run-median. After completion of the chart, add up the total number of strokes and divide this number by 2. Starting at the top level of the chart, count each stroke mark until the mark is reached which corresponds to the number obtained in the above division. The dB level containing this mark is the long-term median.

(b) Plot the data which is recorded in the right-hand column of figure 114-8 (DCA Form (Test) T2-2) on figure 29-4 (DD Form 2099). Enter the median value of each recorded parameter on figure 24-3 (DD Form 2104).



NOTES:

1. SELECT VF CHANNEL ADJOINING VF CHANNEL USED FOR TEST TONE RECORDING, IF POSSIBLE. (SEE TEXT)
2. AUDIO FREQUENCY NOISE GENERATOR IS USED DURING RECORDER CALIBRATION ONLY AND IS TO BE DISCONNECTED DURING ACTUAL RECORDING.
3. THE IMPULSE NOISE METER AND THE NOISE MEASURING SET MAY BE DISCONNECTED DURING THE RECORDING IF THEIR USE IS REQUIRED ELSEWHERE.

Figure 114-1. Idle channel noise recording test setup.

RADIO LINK RECORDED PARAMETERS
IDLE CHANNEL NOISE AND IMPULSE NOISE

PAGE _____ OF _____ PAGES

DATE (day, mo., year)

DATA SHEET T1-3

DCS LINK NO.	TERMINAL RADIO EQUIPMENT	TIME TEST PERIOD START Z	TIME TEST PERIOD STOP Z	TEST ENGR. SIGNATURE

EQUIPMENT TEST POINTS AND POWER LEVELS		DISTANT TRANS.	LOCAL, RECEIVE
	NAME OF SITE		
	TEST POINT NUMBER	TP–	TP–
	TLP { REF. TEST TONE SIG. PWR. (S_T) }		dBm
	RELATIVE TEST SIG. PWR. (S'_T)		dBm0 / dBm

RUN NO.	SG NO.	G NO.	V. CH. NO.	S_m MEAS. TEST SIG. PWR.	IDLE VOICE CHANNEL NOISE: MEASURED RUN–MEDIAN NOISE POWER (N) 3.1KHz FLAT WEIGHTING		C–MESSAGE WEIGHTING		MEDIAN ST/N, dB $S_T - N - S'_T + S_m$ (dBm)(dBm)(dBm)(dBm)		IMPULSE NOISE COUNTS LO	MED	HI	MEDIAN RSL
											dBrn0			
											SET AT dBrn			
				dBm	dBm	dBrn	dBmC	dBrnC	dB FLAT	dB C-MSG.				–dBm

DCA FORM (TEST) MAR 73 T1-3

Figure 114-2. Idle channel noise recording data sheet.

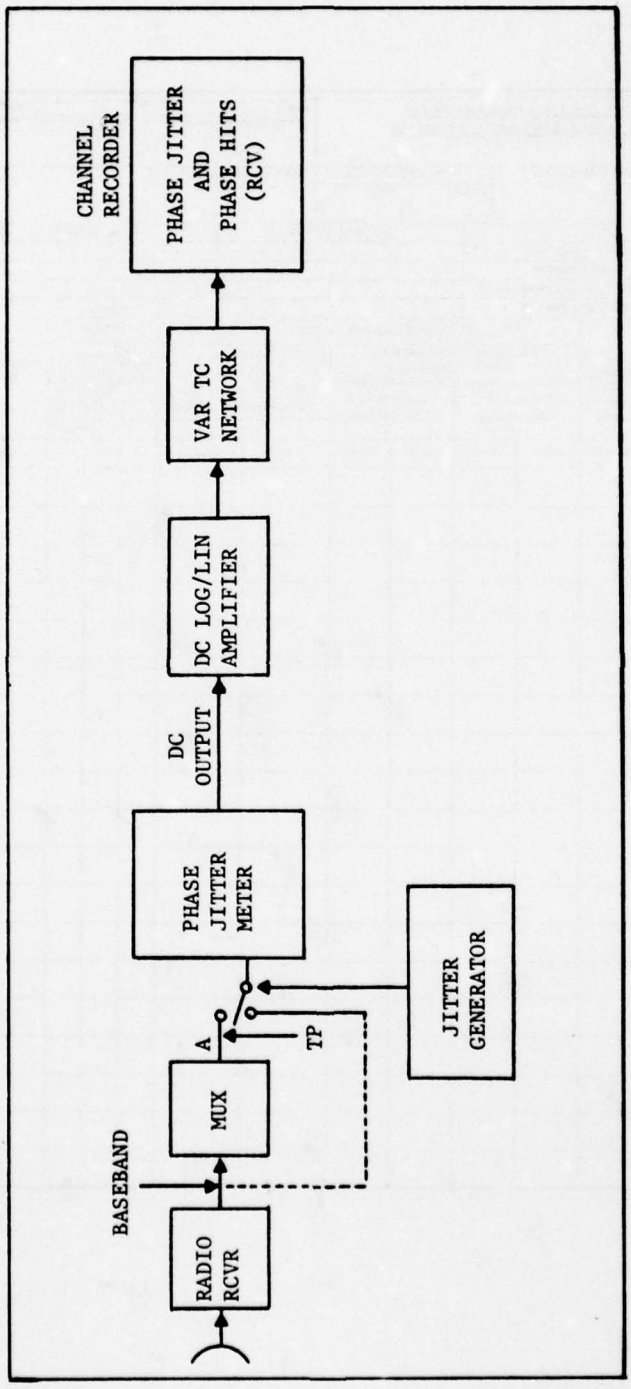


Figure 114-3. Voice channel phase jitter recording test setup.

RADIO LINK RECORDED PARAMETERS
PHASE JITTER AND HITS

PAGE _____ OF _____ PAGES

DATA SHEET T1-4

DATE (day, mo., year)

V.C.H. TEST POINTS (Note any changes between runs on data sheet)

AT TRANS: TP- _____ AT REC: TP- _____

TEST ENGR. SIGNATURE

RADIO LINK STATIONS

STATION UNDER TEST

DISTANT STATION

DCS LINK NO.

TERMINAL RADIO EQUIPMENT

TEST TIME PERIOD

START Z STOP Z

RUN NO.	TEST RUN TIME Z		DUR. OF RUN, MIN.	CHART SPEED MM/MIN.	SG NO.	G NO.	V. CH. NO.	VOICE CH. PHASE JITTER & HITS (IMPULSES)							
	START	STOP						PHASE JITTER		NUMBER OF PHASE HITS (IMPULSES) AT THE INDICATED PHASE LEVEL					
								PEAK TO PEAK	AVE.	DEGREES					
										5	10	15	20	25	

DCA FORM (TEST) MAR 73 T1-4

Figure 114-4. Phase jitter and phase hits recording **data sheet.**

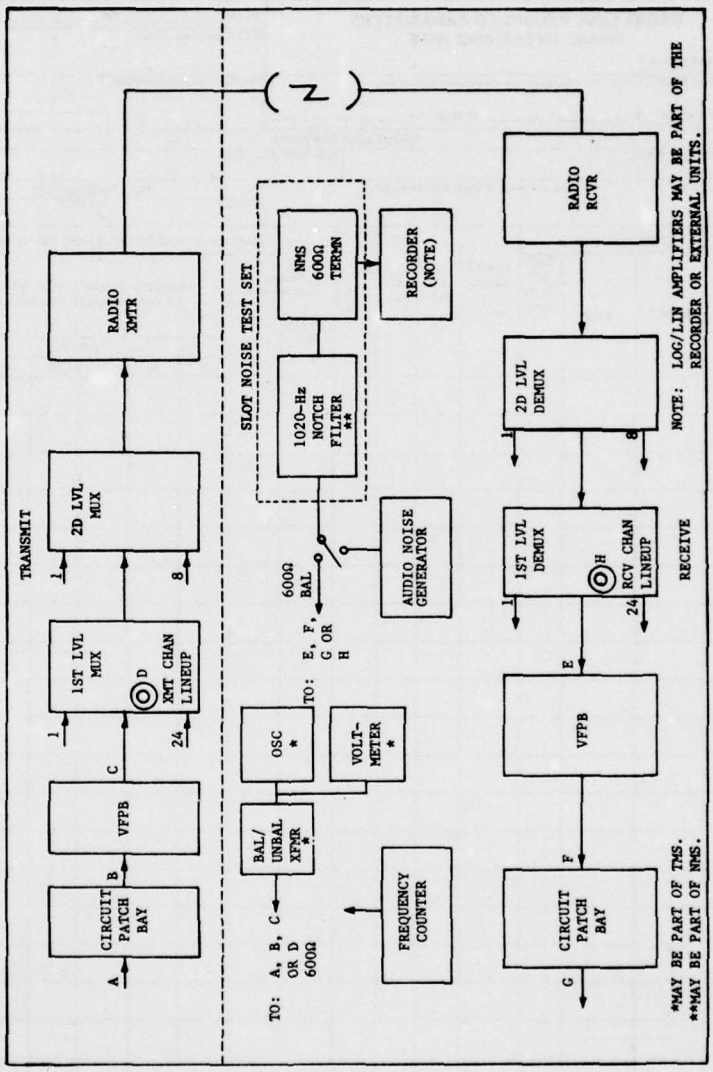


Figure 114-5. Signal-to-noise quantizing recording test setup.

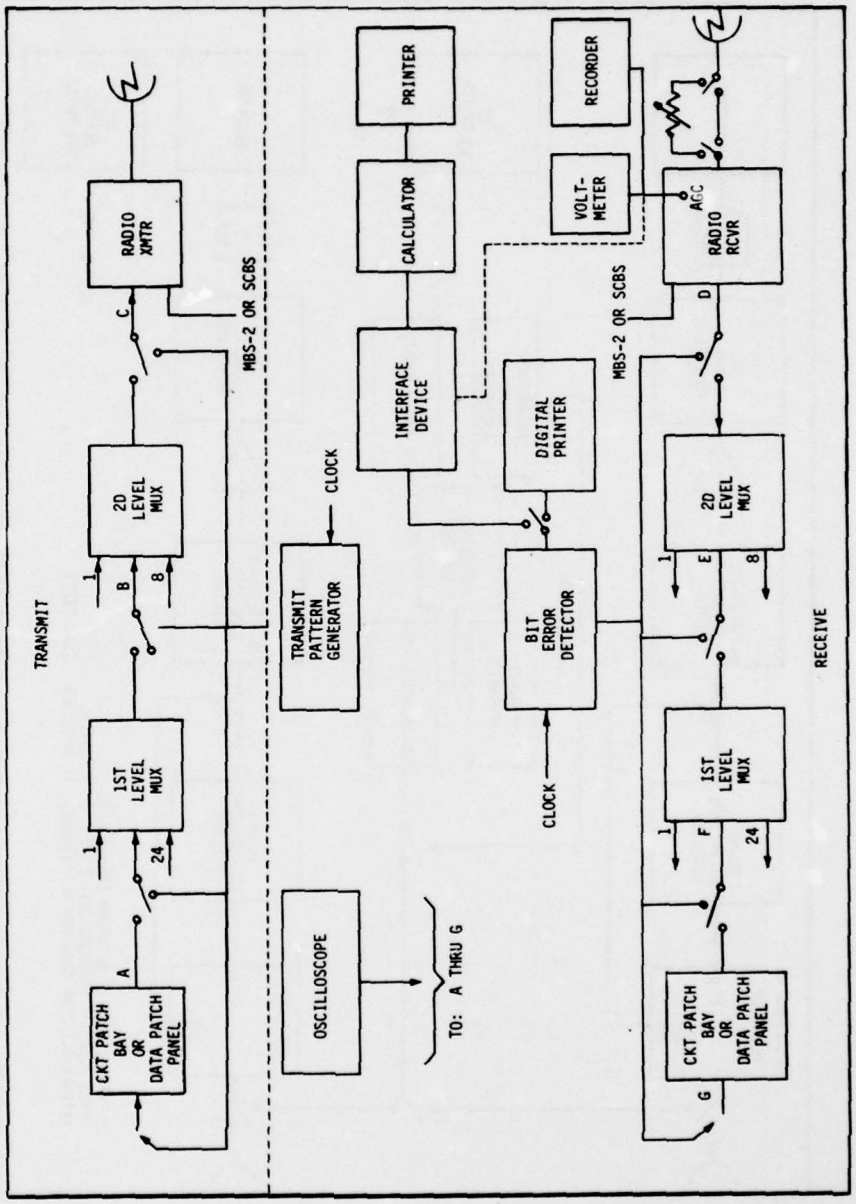


Figure 114-6. BER recording test setup.

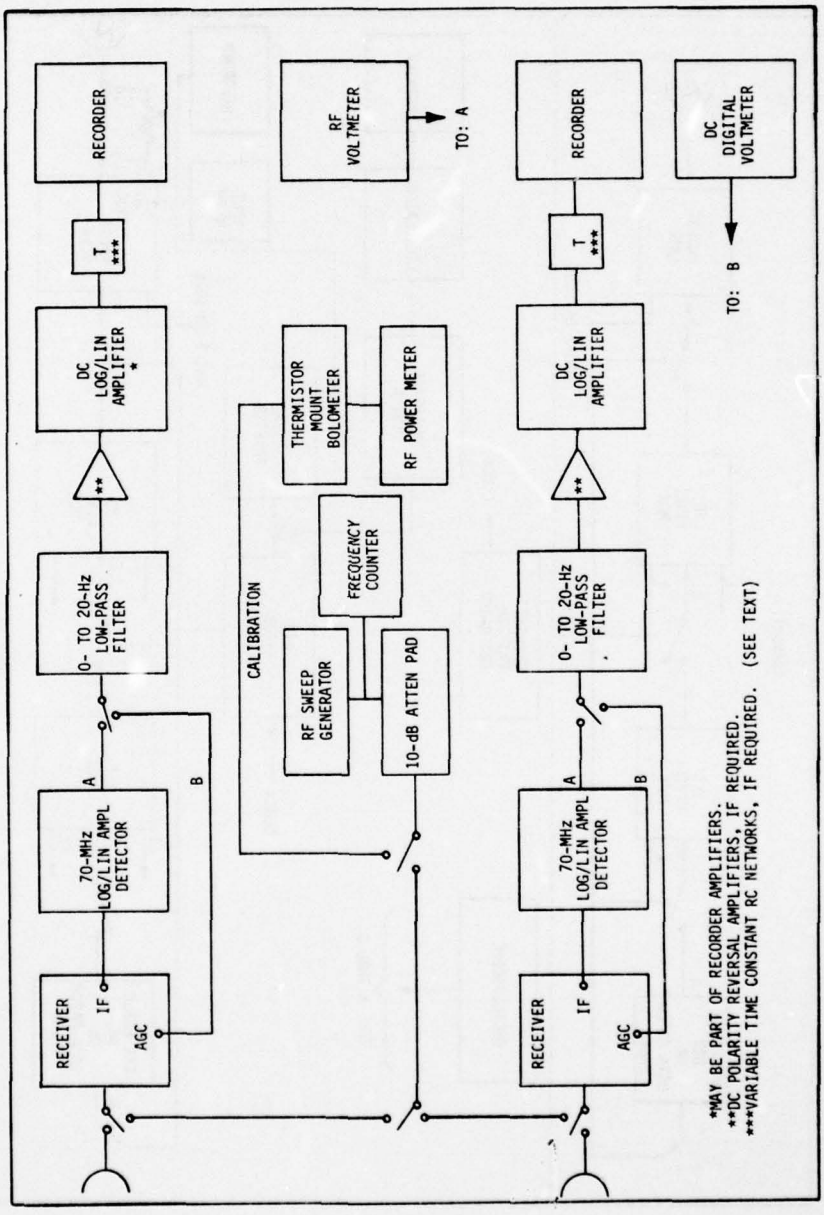


Figure 114-7. RSL recording test setup.

CUMULATIVE AMPLITUDE PROBABILITY DISTRIBUTION STROKE CHART

PAGE _____ OF _____ PAGES

DATE (day, mo., year)

DATA SHEET T2.2

DCS LINK NO.	STATION UNDER TEST	TEST ENGR. SIGNATURE

RUN NUMBERS	DURATION OF RUNS	RADIO RCVR.
FROM _____ THRU _____	_____ MIN.	NO. _____

RUN MEDIAN RSL, dBm	NUMBER OF RUN MEDIANS AT THE INDICATED VALUE	
	INDIVIDUAL-RUN STROKES	TOTAL NO. OF STROKES

TOTAL NUMBER OF RUNS = _____ TOTAL TIME = _____ MIN.

LONG TERM MEDIAN: RSL = _____ dBm; NOISE = _____ dBm0; $\frac{S}{N}$ = _____ dB

DCA FORM (TEST) MAR 73 T2-2

Figure 114-8. Probability distribution stroke chart (RSL) data sheet.

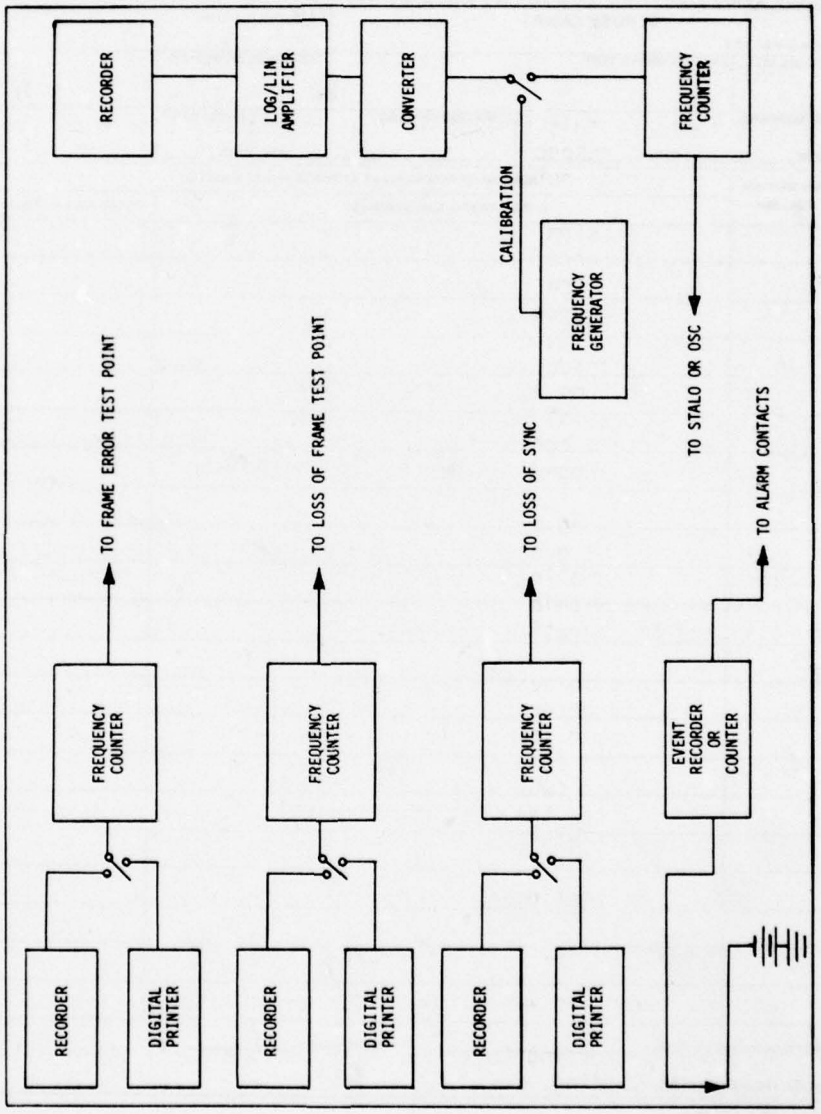


Figure 114-9. Miscellaneous recording parameters.

CHAPTER 115

RESISTANCE OF STATION GROUND AND STATION NOISE (DT-312)

115-1. GENERAL.

a. The purpose of this test is to measure the resistance of the station grounding system with respect to true earth ground and the level of noise present on the grounding network.

b. An adequate station ground and ground distribution system provides a common electrical reference point for all equipment at the station. It also eliminates or minimizes the potential between individual equipment, and between the equipment and earth ground.

c. The earth electrode subsystem provides the common reference for all other grounding subsystems at a facility. The ground potential is established by means of an electrode(s) buried in the earth. At many communications facilities, the ground system consists of buried rods interconnected with bare wire to form a ring ground around the station or facility.

d. The station ground system will normally encompass the signal ground subsystem, AC protective ground subsystem, and the lightning protection subsystem. An improperly installed or ineffective grounding system can result in noise being generated within the station thereby degrading communications and creating a hazard to operating personnel.

e. The first step in evaluating a station ground system is to review all applicable drawings to determine the type of grounding system installed or to be installed. The second step is to check the records of ground resistance measurements. The third step is to compare the actual grounding details to the engineering drawings (where accessible). The third step is most important at stations or facilities that have been installed for a considerable period of time. Such documentation should include a review of:

(1) Lightning protection grounding.

(2) Station grounding.

(3) Antenna tower and waveguide bridge grounding.

(4) AC power generating facility, fuel tank, and all other external structure grounding and bonding.

(5) Interior equipment grounding and bonding details.

115-2. SPECIFICATIONS.

a. The station grounding system shall conform to the standard engineering plan or contract specifications.

b. As a design objective, the impedance to earth ground shall be 5 ohms or less. (FM 11-490-9)

c. Unless otherwise specified, wideband noise shall be 100 mV or less. (FM 11-490-9)

115-3. TEST EQUIPMENT REQUIRED.

a. Earth tester with accessories.

b. Oscilloscope.

c. Wave analyzer.

d. Ground fault interrupter.

e. Clamp-on ammeter.

115-4. TEST PROCEDURES.

a. Earth Resistivity.

(1) Use a null-balance tester to determine the resistivity of the earth (fig. 115-1). Drive a ground rod (C2) into the earth at a considerable distance from the earth electrode (C1). Crank the hand generator which is part of the null-balance tester to send a current through the earth between the two electrodes. Connect the P2 rod to the galvanometer of the tester and the rods driven into the ground at various points along a straight line between C1 and C2. Adjust the digital balancing resistance at each of these points for a center reading on the galvanometer to obtain corresponding resistance readings. Plot these readings as shown in figure 115-2.

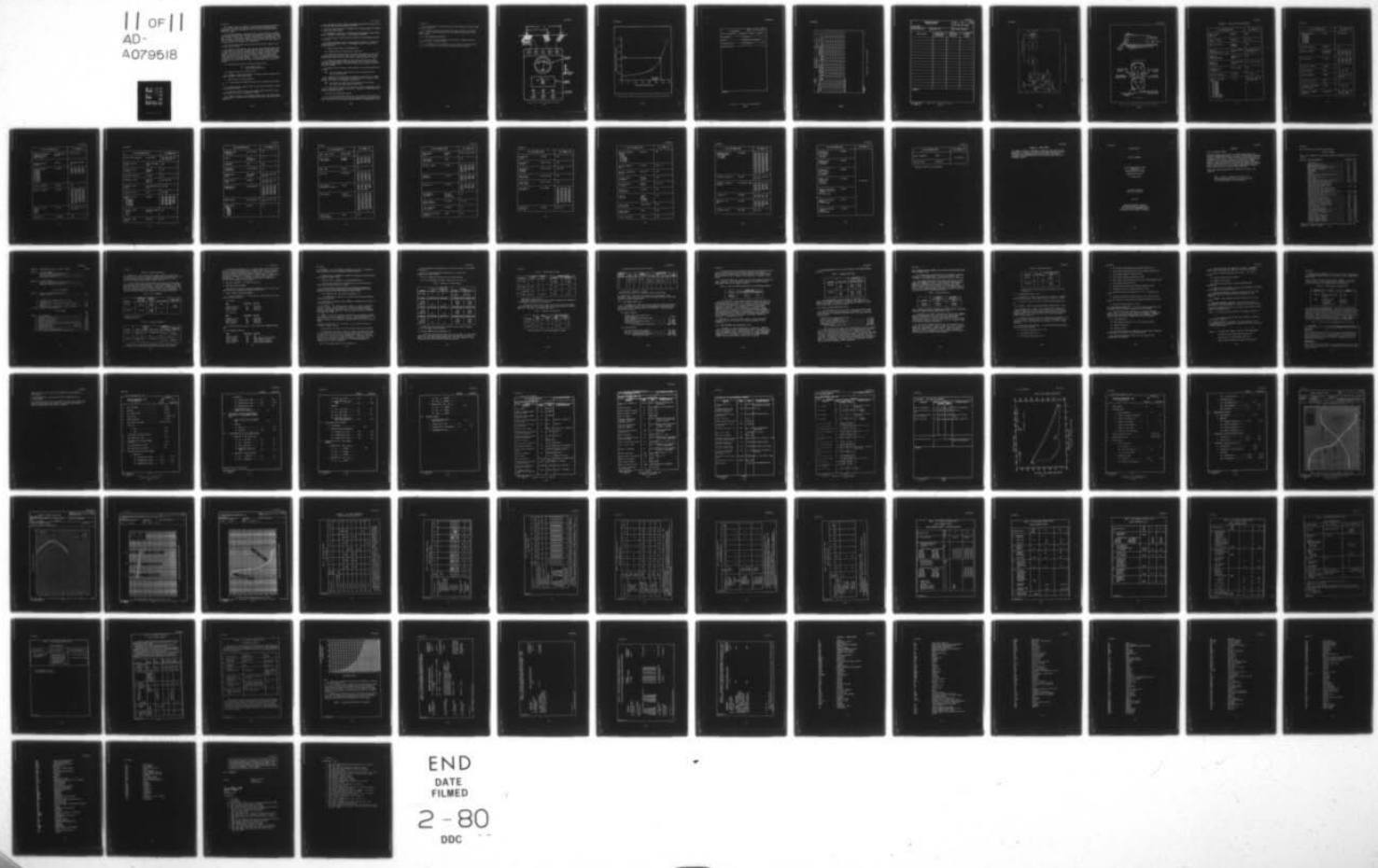
NOTE: If the test readings are plotted against the distance from C1, the resulting curve will show that the ground resistance between C1 and P2 increases to a certain point, levels off, and then increases again as C2 is approached provided C2 is placed far enough away from C1. The true resistance to earth at electrode C1 is the value at the leveled-off portion of the curve before it is influenced by rod C2. This point will normally be reached approximately 62 percent of the distance between rods C1 and P2. If the curve does not level off, place rod C2 at a greater distance from rod C1.

(2) Drive the first reference rod (C2) approximately 2 feet into the ground as far from C1 as possible. This distance may be limited by the geography of the surrounding area; however, table 115-1 should be used for locating rods P2 and C2.

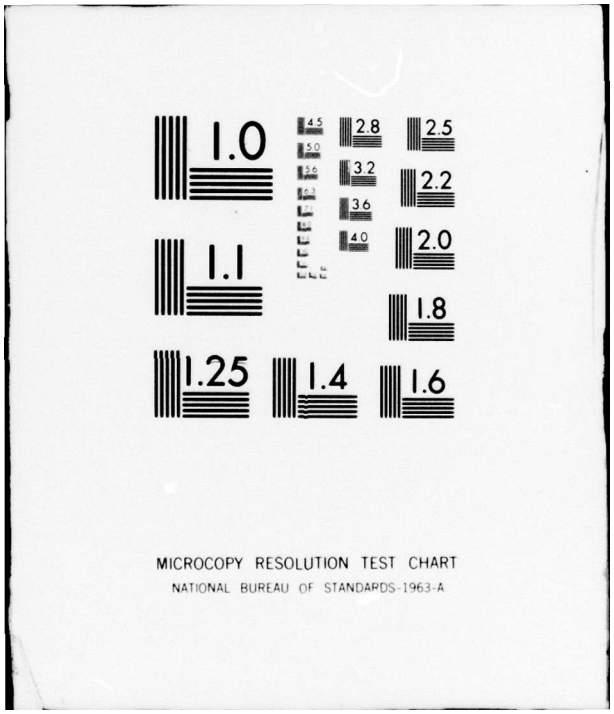
Table 115-1. Guide of Location of Reference Ground Rods

DIAGONAL DIMENSION (feet)	DISTANCE E TO P2 (feet)	DISTANCE E TO C2 (feet)
4	62	100
6	78	125
8	87	140
10	99	160
12	105	170
16	124	200
18	130	210
20	136	220
40	198	320
60	242	390
80	279	450
100	310	500
120	341	550
140	366	590
160	397	640
180	422	680
200	440	710

AD-A079 518 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA AZ F/G 17/2.1
DIGITAL RADIO AND MULTIPLEX TEST PROCEDURES.(U)
SEP 79
UNCLASSIFIED ACC-CCP-702-11 NL



END
DATE FILMED
2-80
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(3) Connect a wire to C1 and P1 of the tester and connect these terminals to the earth electrode to be measured. The wire used for connecting the instrument to the earth electrode should be at least #12 American Wire Gage (AWG) solid copper.

(4) Drive the potential reference rod (P2) into the ground on a straight line between C2 and the earth electrode to be measured at a distance of 62 percent as shown in figure 115-1. The wire connecting C2 to the tester will be #6 AWG to provide a low resistance compared to the resistance to be measured. The size of the wire connecting P2 to the instrument will not affect the reading at balance; therefore, if desired, use a smaller size.

(5) Set the tester range switch to X0.01 and the digital readout of the balancing network to 999.

(6) Slowly turn the generator crank and note the galvanometer deflection. If the deflection is positive, increase the range factor of the tester to X0.1 or higher until the deflection becomes negative. When the deflection becomes negative, decrease the value of the instrument balancing resistor (digit-by-digit) starting with the left-hand knob, then the center, and finally the right-hand knob until the galvanometer is nulled. The galvanometer must be cranked while all adjustments are made. The cranking speed will be a minimum of 160 revolutions per minute (RPM) and for maximum sensitivity in excess of 200 RPM.

(7) Determine the resistance from the following formula:

$$R_{C1} = \text{dial reading} \times \text{range factor reflected on tester}$$

(8) Complete figure 115-3 (DD Form 2129).

(9) Complete the ground measurements at the points shown on figure 115-4 (USACC Form 686-R). Record the results.

b. AC/DC Currents on Ground Conductors.

(1) Set the clamp-on AC ammeter function switch to measure 0 to 15 amps AC.

(2) Clamp around the conductor under test and note the reading on figure 115-5 (USACC Form 687-R).

(3) Check for current in each primary feeder exercising caution to preclude inadvertent contact with dangerous voltages.

(4) Check for current in each equipment ground lead, inside and outside ground conductors, waveguides, AC protective wires (green), and other points as required.

(5) To measure for DC currents on equipment designed with the plus side of the DC power supply grounded, proceed as follows:

(a) Plug in the clip-on DC milliammeter and allow approximately 30 minutes for warmup and stabilization.

(b) Demagnetize the probe in accordance with the equipment service manual and set the meter to read 10 amps. Zero the meter indicator.

(c) Clip the probe around the ground conductor of the equipment and note the reading.

(d) Change the meter scale to a more sensitive position if a reading is not obtained. Record the results in the comments section of figure 115-5 (USACC Form 687-R).

c. Voltage, Output Ripple, and Wideband Noise.

(1) Establish the test setup shown in figure 115-6.

(2) Connect the center conductor and cable shield together at the earth electrode end (station ground). With a heavy duty electrical clamp or clip, connect these wires to the electrode system. Ensure good metallic contact.

(3) Connect the center conductor of the earth electrode cable to the shield of the oscilloscope or wave analyzer test lead. At this point and at the common (ground) terminal of the oscilloscope or wave analyzer, leave the shield unterminated.

(4) Connect the oscilloscope or wave analyzer to the battery-powered test equipment.

NOTE: The oscilloscope or wave analyzer should be powered from its own internal DC source.

(5) Adjust the oscilloscope or wave analyzer sensitivity for a suitable display. Sequentially clip the center conductor of the oscilloscope or wave analyzer test leads to the equipment to be measured.

NOTE: Ensure that the shield of the test cable does not touch the hot leads of the power supplies under test.

(6) With the oscilloscope or wave analyzer, measure the amplitude and frequency of the highest voltage or noise level. Record this information on figure 115-5 (USACC Form 687-R).

d. AC Wiring at Convenience Outlets.

(1) Use the tester shown in figure 115-7 to determine if the ground, the AC neutral, or the AC hot wires have been reversed at convenience and wall outlets. The tester will also reflect any open condition of the ground or lines.

(2) Plug the tester into the various outlets and check the indicator lamps for proper operation.

(3) Record any problems reflected by the tester on figure 3-7 (DD Form 2091). Provide a detailed description of the condition and location of the outlets tested.

115-5. DATA RECORDING AND ANALYSIS.

a. Review all data for completeness and accuracy. Summarize the test results on figure 3-7 (DD Form 2091).

b. If grounding or noise problems are noted, report all pertinent information to the appropriate activity for required corrective actions.

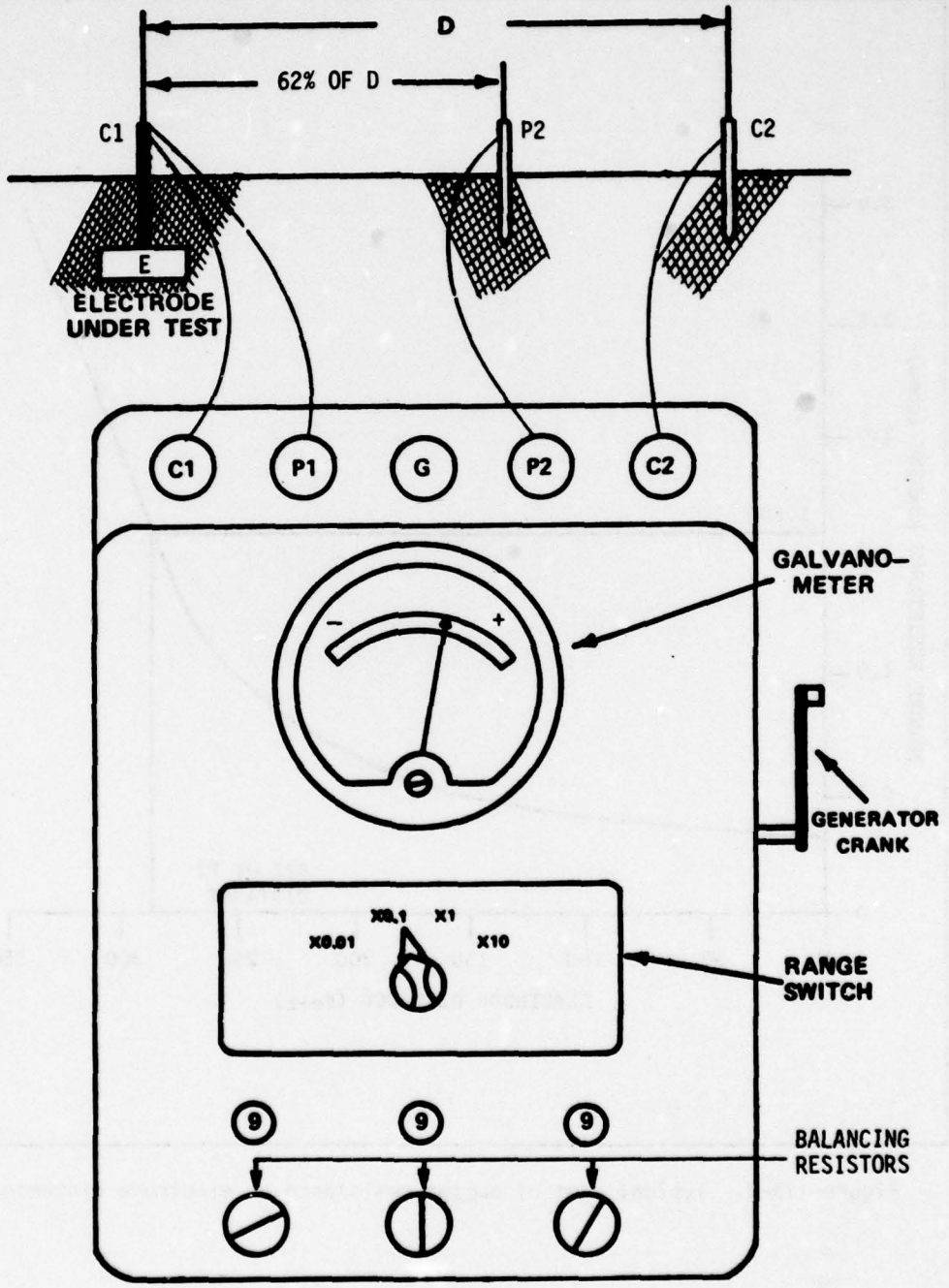


Figure 115-1. Earth resistance test setup.

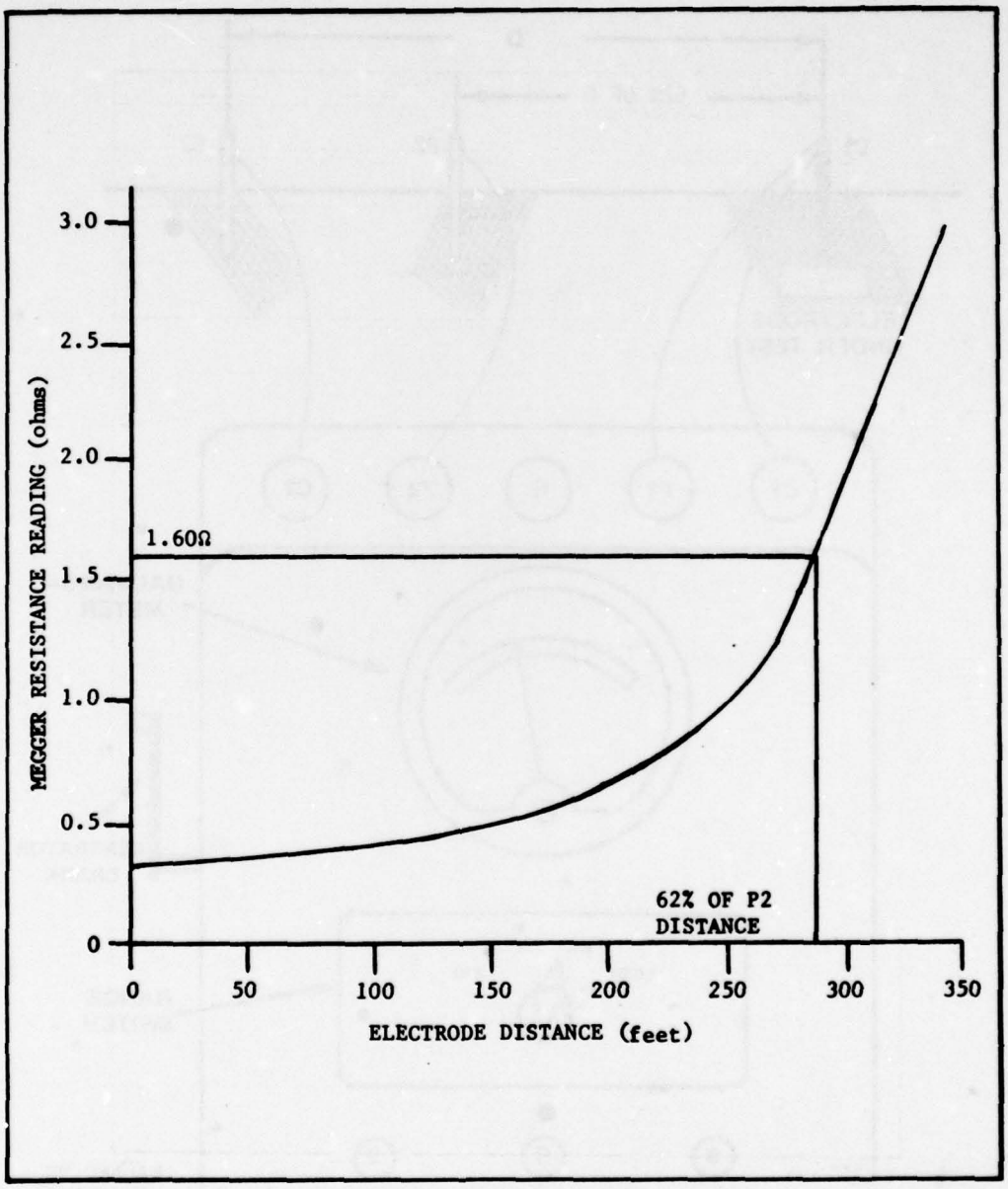


Figure 115-2. Typical plot of megger resistance vs electrode distance.

STATION GROUND DATA			PAGE ____ OF ____ PAGES DATE	
DCS LINK NO.	STATION UNDER TEST	DISTANT STATION	ENGR. INIT.	TECHN. INIT.

DIAGONAL DIMENSION	DISTANCE E–C_2
DISTANCE E–P_2	RESISTANCE TO EARTH OF STATION GROUND Ohms
STATION GROUND CONDUCTOR	CHEMICAL TREATMENT
DESCRIPTION OF INSTALLATION	

DD FORM 1 SEP 77 2129

Figure 115-3. Station ground data sheet.

GROUNDING (CCR 702-1-3) DATA SHEET				STATION/OPERATING UNIT						PAGE OF PAGES									
				TEST ENGR SIGNATURE						DATE (DAY, MO, YEAR)									
DISTANCE (FEET)	TOWER LEGS		WAVEGUIDE BRIDGE SUPPORT	OPERATIONS BUILDING					AC POWERHOUSE GROUNDS							FUEL TANKS	OTHER
	NE	SW		BLDG GND EXT	GND BOX INTR	TCP PTP	RDO MUX	FRAME	AC PROT GND	AC NEUT GND	GEN 1	GEN 2	GEN 3	EXT GND	OTHER		
COMMENTS (ALL READINGS IN ohms)																	

USACC FORM 686-R
1 MAY 79

Figure 115-4. Grounding data sheet.

GROUNDING WORKSHEET (CCR 702-1-3) DATA SHEET		PAGE OF PAGES
		DATE (DAY, MO, YEAR)
STATION UNDER TEST	OPERATING UNIT	TEST ENGR SIGNATURE

TEST LOCATION	RIPPLE AND WIDEBAND NOISE (mV p-p/Hz)	VOLTAGES AT TEST POINTS (VAC/VDC)	DC CURRENTS IN GND CNDCT (amps)

COMMENTS

USACC FORM 687-R
1 MAY 79

Figure 115-5. Grounding worksheet.

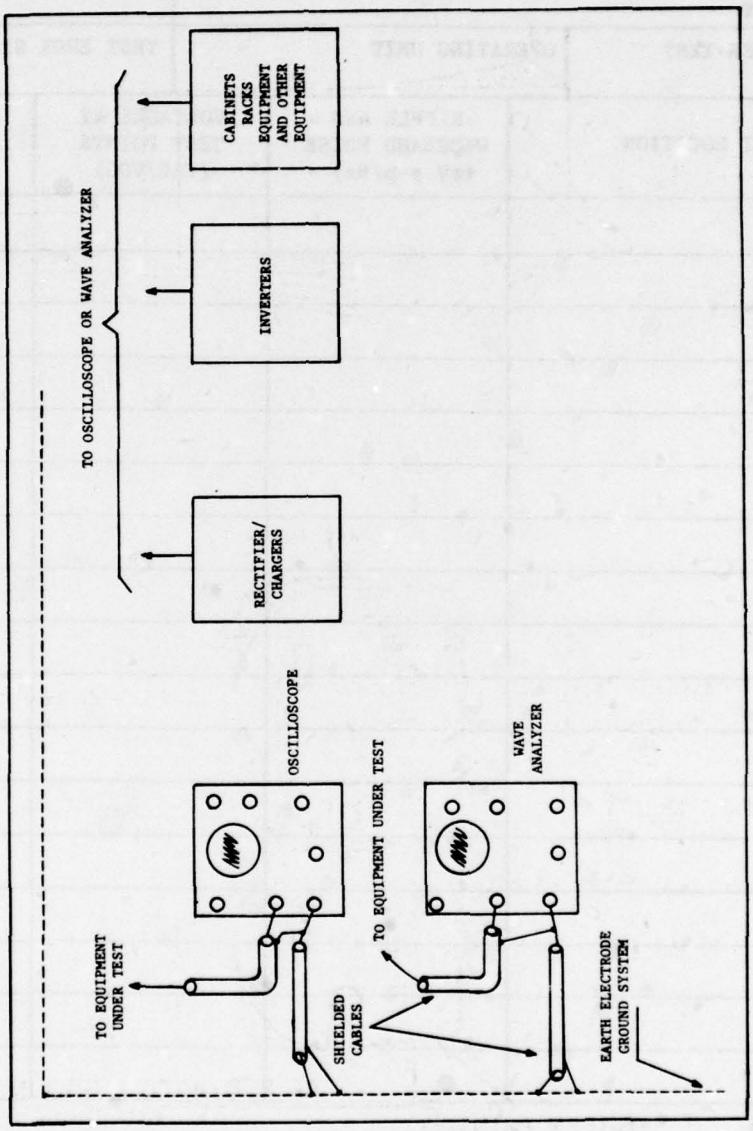
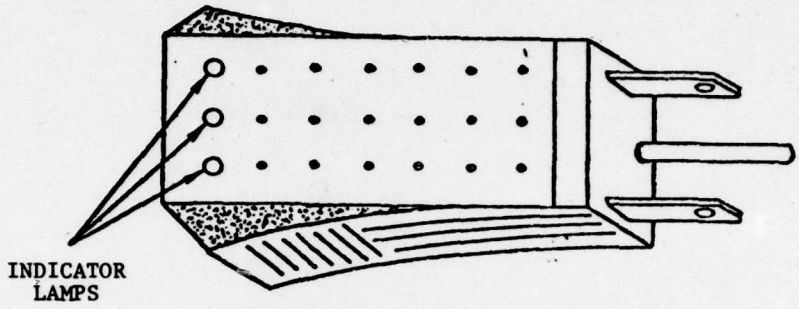
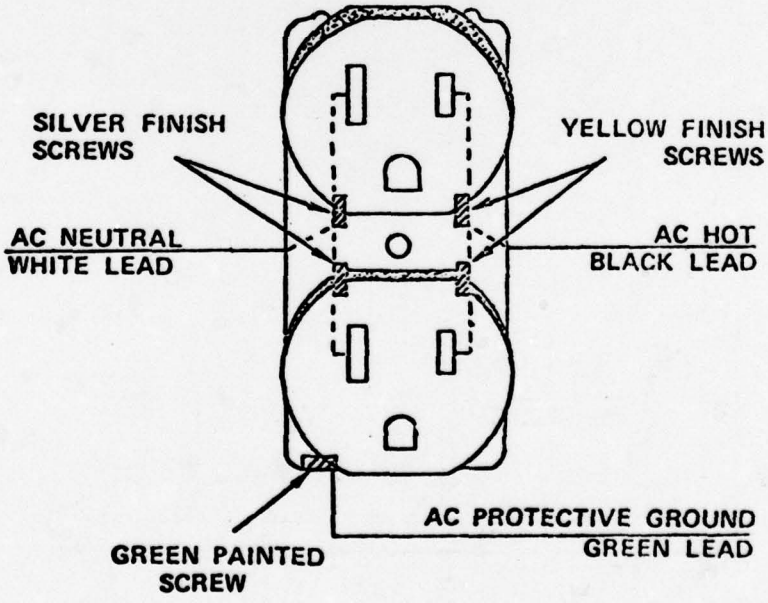


Figure 115-6. Ripple and wideband noise test setup.



a. AC fault locator.



b. Outlets.

Figure 115-7. Typical AC fault locator and outlets.

APPENDIX A. SPECIFIED TMDE OR EQUIVALENT

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Adder, 75-ohm Resistive	Raytheon	288
Ammeter, Clamp-on	AN/GSM-66	309, 312
Amplifier, 26 dB	Raytheon 314677G3	288
Amplifier, Logarithmic/Linear, 70 MHz	Varian Associates ITL-2	200, 224, 258, 263, 278, 283, 311
Amplifier Polarity Reversal	Clevite Prush 268862	200
Amplifier Wideband RF	To be determined (TBD)	218, 219, 232, 259
Analyzer, Delay (Linearity)	Collins (TBD)	219
Analyzer, Distortion	HP 3334A	271, 310
Analyzer, Microwave Link HP 3702A* HP 3705A* HP 3703B* HP 3730A* HP 3736A* HP 3737A* HP 3738A* HP 3739A* HP 37301A* HP 3715/3703B* HP 3716/3705A*	HP 3710	218, 219, 234, 235, 256, 257, 259

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Analyzer, Spectrum HP 8552B* HP 8443A* HP 8444A* HP 8555A* HP 8445B* HP 8406*	HP 141T	203, 204, 242
Analyzer, Spectrum	HP 3040A	209
Analyzer, Spectrum	HP 8565A/TEK 491 or 492	202, 213, 220, 221, 222, 223, 227, 232, 234, 237, 238, 242
Analyzer, Wave	HP 3580	213, 214, 215, 260, 264, 267, 271, 272, 274, 279, 284, 312
Attenuator, Variable	HP 3750A	288
Autotransformer	(TBD)	246, 308, 310
Bridge, Impedance	HP 250B	212, 215, 225, 255, 280, 293
Bridge, Return Loss	(TBD)	214
Calculator, Programmable w/Interface Bus	HP 9825	274, 283, 292
Camera, Oscillograph w/adapter	TEK C27/C30	202, 204, 218, 220, 221, 222, 238

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Chamber, Environmental w/Temperature and Humidity Sensors	Per contractor design	236, 253, 292
Converter, Digital-to-Analog	CV 3034	221, 236, 253, 261 292
Counter Frequency HP 5301A* HP 5302A* HP 5303B* HP 5304A* HP 5305B* HP 5306A* HP 5307A* HP 5308A*	HP 5300B	263, 264, 269, 270, 276, 282, 283, 286, 287, 298, 304, 305, 307, 308, 310, 311
Counter, Frequency	HP 5326A	288
Counter, Frequency	HP 5340A	202, 203, 204, 206, 207, 208, 209, 210, 211, 216, 217, 218, 221, 224, 225, 227, 228, 234, 235, 236, 237, 238, 239, 240, 241, 242, 244, 249, 253, 255, 256, 260, 261, 292, 299, 300, 303, 311
Detector, Crystal G423* J423* H423*	HP 423A	203, 204, 207, 238 241, 242
Detector, RF	HP 11664A	205

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Display Unit, Spectrum	Sierra 360B	208, 213, 220, 224 258, 267, 272
Filter, Low-Pass 20 Hz	White Instrument (TBD)	200
Filter, Low-Pass 4.4 MHz	Raytheon 898018	288
Generator, Function	HP 3325A	301
Generator, Jitter	Hekimian Model 75	212, 301, 311
Generator, Noise (Spike)	Local fabrication or HP	245, 253
Generator, Pulse	HP 214	254, 306
Generator, RF/IF Sweep HP 86220A* HP 86230B* HP 86241A* HP 86245A* HP 86260A*	HP 8620C	200, 202, 203, 204, 205, 206, 207, 211, 218, 221, 224, 227, 228, 232, 236, 238, 239, 241, 242, 243, 253, 255, 258
Generator, Signal LDS-1* LDE-1* GS-1*	Wandel-Goltermann TS-PS-42	209
Generator, Sweep (Audio)	Acton 490	260

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Generator, Test (Linearity)	Collins (TBD)	219
Hybrid	Collins 059-0006-505	214
Hydrometer	(TBD)	309
Interrupter, Ground Fault	Local Purchase	312
Measuring Set, Delay	Acton 490B/ HP 4940A	213, 215, 263, 268 269, 278
Measuring Set, Noise	HP 3555B	215, 265, 267, 276, 307, 308, 311
Measuring Set, Transmission	HP 4940A/3550B	213, 215, 255, 262 263, 264, 265, 266, 267, 270, 271, 272, 273, 276, 278, 279, 280, 281, 282, 283 284, 285, 295, 304 311
Meter, Jitter	Hekimian Model 74	212, 225, 291, 301 311
Meter, Noise Figure G347A* H347A* J347A* P347A* X347A*	HP 342A	223

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Meter, Phase Jitter	Hekimian 48A3	311
Meter, Power Power Sensor	HP 436A HP 8484A	200, 202, 207, 218, 221, 227, 230, 233, 239, 241, 242, 249, 255, 258, 259, 303, 311
Meter, SWR	HP 415E	207
Oscillator	HP 651B/654	206, 208, 210, 213, 214, 215, 220, 221, 222, 228, 234, 235, 237, 244, 249, 253, 261, 173, 284, 293, 303, 306, 307, 308
Oscilloscope w/Differential Amplifier	TEK 465	291, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 305, 306, 307, 308
Oscilloscope	TEK 475A or 7000 series	206, 207, 209, 210, 211, 212, 213, 219, 222, 225, 228, 229, 230, 231, 234, 235, 241, 243, 245, 246, 248, 249, 250, 252, 254, 255, 261, 262, 263, 264, 265, 266, 270, 273, 274, 275, 281, 286, 287, 288, 289, 304, 310, 311, 312
Power Source, Fixed Frequency	(TBD)	246

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Power Supply, 48 VDC	Sorenson (TBD)	245, 247, 253, 274
Power Supply, Variable AC	(TBD)	310
Recorder, Digital	HP 5055	207, 216, 217, 221, 226, 236, 249, 253, 285, 286, 287, 289, 290, 292, 298, 301, 306, 311
Recorder, Stripchart	HP 7418A	200, 221, 226, 236, 244, 253, 283, 286, 288, 289, 290, 292, 310, 311
Recorder, X-Y	HP 7035B	202, 206, 207, 213, 215, 222, 238, 241, 242, 245, 260, 263, 268
Reflectometer, Time Domain	TEK 1503/ Scientific Atlanta 1691	201
Short, coaxial, 50-ohm, N-Female	HP 11511A	202, 204
Short, Waveguide 7 to 10 GHz	HP H920A	202
Simulator, Pulse-Code Modulation	(TBD)	212

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Termination, Coaxial	HP 910B	205
Test Fixture DC Spike	Refer to text	246
Test Fixture, Frequency Transient	Refer to text	246, 248
Test Fixture, Overvoltage	Refer to text	246
Test Fixture, Undervoltage	Refer to text	246
Test Set, Bit Error Rate	Aydin 604M	207, 210, 212, 213, 220, 222, 225, 226, 228, 229, 230, 232, 244, 245, 248, 249, 250, 252, 254, 255, 261, 286, 287, 289, 290, 291, 293, 294, 296, 297, 298, 299, 300, 301, 302, 304, 305, 306, 307, 308, 311
Test Set, Bit Error Rate	HP 1645	285, 311

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Test Set, Frequency Response HP182T* HP 8750A* HP 11666A* HP 11678A* HP 11679A*	HP 8755S	205
Test Set, Impulse Noise	TTS-58A	266, 311
Test Set, Longitudinal Balance	Wiltron 94	284
Test Set, Noise, W/TK-2045G	Marconi OA-2090C	288
Test Set, Noise, 12-channel	Marconi TM 7816	261, 311
Test Set, Reflectometer	HP 8326A	203
Test Set Signaling	Lenkurt 26600/ Northeast TTS-4BNH	273
Tester, Earth w/accessories	Biddle 63220	312
Tuner, Coaxial, Double Stub	(TBD)	201
Tuner, Slide Screw	(TBD)	207

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Voltmeter, Digital (AC/DC Ohmmeter) HP 2802A* HP 34740A*	HP 34702A	221, 224, 227, 228, 229, 230, 231, 232, 234, 235, 237, 239, 240, 244, 245, 246, 247, 249, 250, 252, 253, 254, 255, 258, 260, 263, 264, 265, 266, 263, 264, 265, 266, 267, 270, 271, 272, 274, 275, 276, 278, 279, 280, 281, 282, 283, 284, 290, 295, 302, 303, 307, 308, 309, 310
Voltmeter, Electronic	HP 410C	200, 210, 219, 226 241, 242
Voltmeter, Frequency Selective	HP 312/Sierra 128A	208, 209, 211, 213, 214, 215, 216, 217, 220, 221, 224, 231, 235, 237, 258, 260, 264, 267, 270, 272, 278, 279
Voltmeter, RF	HP 3406A	212, 225, 227, 238 242, 255, 303, 311
Voltmeter, True RMS	HP 3400	200, 207, 208, 211, 213, 214, 215, 234, 243, 249, 255, 256, 261, 288, 293
Voltmeter, Vector	HP 8405A	206, 293

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Attenuator, RF DC to 18 GHz 0 to 11 dB in 1-dB steps	HP 8494B	As required
Attenuator, RF 0 to 70 dB in 10-dB steps	HP 8495B	
Attenuator, RF DC to 18 GHz 0 to 110 dB in 10-dB steps	HP 8496B	
Coupler, Dual Directional (coaxial) 2 to 18 GHz	HP 11692D	
Coupler, Directional (frequency determining, coaxial) 1.7 to 12.4 GHz	HP 779D	
Coupler, Directional Waveguide 3.7 to 5.5 GHz	HP G752	
Coupler, Directional Waveguide 7.05 to 10 GHz	HP H752A	

TITLE AND NOMENCLATURE		TEST NUMBER (DT)
Mixer, Turnaround	(TBD)	As required
Splitter, Power	HP 11667A	

*Selection based on test requirements.

APPENDIX B. SAMPLE REPORT

This appendix contains a representative sampling of test reporting and evaluation. In addition, guidelines are furnished regarding individual responsibility for preparation of certain portions of the report. Deviations from established format will be cleared through applicable management channels.

CCP 702-11

ACC-QATD-107-79

QUALITY ASSURANCE

DEFENSE COMMUNICATIONS SYSTEM
LINK M-0124
BAYBERG-DACHSTEIN, GERMANY

WIDEBAND RADIO ANALYSIS

(1-16 MARCH 1979)

TECHNICAL EVALUATION
(RCS: DCA (AR) A070-1)

MAY 1979

PROTECTIVE MARKING IS CANCELED
UPON RECONFIGURATION OR MODIFICATION
OF THE FACILITY OR EQUIPMENT WHICH
INVALIDATES THE DATA (PARA 12, AR 340-16)

ABSTRACT

(Will be prepared by QATD)

The Defense Communications System link M-0124 between Bayberg and Dachstein, Germany was tested and evaluated in accordance with Supplement 1, DCA Circular 310-70-57, Technical Evaluation Line-of-Sight (LOS) and Tropospheric Scatter Links. Analysis of the measured data demonstrates that this link is providing satisfactory service to the customer. However, a number of deficiencies were noted that impact on the quality of service provided by this link. Correction of this deficiency and the others listed in table 12 will enable the link/equipment to perform within specifications and increase system reliability.

(Team chiefs may make suggestions for items to be included in the abstract.)

(NOTE: A copy of a suggested distribution list with complete address of each unit will be included in the data package sent to the datachment.)

(Will be prepared by QATD operations personnel.)

TABLE OF CONTENTS

(This is not a complete listing, however pertinent paragraphs for part one are listed.)

PART ONE. EVALUATION NARRATIVE	Paragraph	Page
Introduction	1.0	B-6
Dates of Evaluation	1.1	B-7
O&M Agency Mailing Address	1.2	B-7
USACC Technical Evaluation Personnel	1.3	B-7
Key Personnel Contacted	1.4	B-7
References	1.5	B-8
Test Results	2.0	B-8
Summary	2.1	B-8
Multiple Parameter Data Recordings (T-1)	2.2	B-9
Audio Tests	2.3	B-11
Idle Channel Noise (T-8)	2.3.1	B-11
Radio Tests	2.4	B-12
Radio Equipment Noise Power Ratio (T-22)	2.4.1	B-12
Radio Link Noise Power Ratio (T-23)	2.4.2	B-13
Transmitter Radio Frequency (RF) Power Output and Antenna System Reflected Power (T-30)	2.4.3	B-14
Receiver FM Quieting, Automatic Gain Control (AGC)/IF, and Direct Current (DC) Control Voltage Characteristics (T-34)	2.4.4	B-14
Receiver Noise Figure (T-36)	2.4.5	B-15
Receiver IF Amplifier and Discriminator Characteristics (T-39)	2.4.6	B-15
Tests That Met Specifications	2.5	B-15
Miscellaneous Observations	2.6	B-16
Equipment Performance Indicators	3.0	B-17
Transmission Quality Indicators	4.0	B-17
Omitted and/or Incomplete Tests	5.0	B-18
Conclusions and Recommendations	6.0	B-18
Data Tabulation	7.0	B-19
Link Data Tabulation-LOS	7.1	B-20
Line-of-Sight Worksheet	7.1.1	B-24
Link Noise Performance Worksheet	7.1.2	B-25
Echo Distortion Worksheet	7.1.3	B-27
Path Profile	7.1.4	B-29
Station Data Tabulation-LOS	7.2	B-30
Station Diagram, Bayberg	7.2.1	Not
Antenna Diagram, Bayberg	7.2.2	incl
Station Diagram, Dachstein	7.2.3	in
Antenna Diagram, Dachstein	7.2.4	sample

(Other data should be included such as voice multiplex diagram, onsite test equipment, or channel breakout.)

PART TWO. EVALUATION DATA (Not included in sample.) Page

Section I. Link Data, Bayberg
Multiple Parameter Data Recordings (T-1).....
1-kHz Test Tone Signal Levels (T-4).....
Idle Channel Noise (T-8).....

* * * * * * *

Section II. Link Data, Dachstein.....
Multiple Parameter Data Recordings (T-1).....
1-kHz Test Tone Signal Levels (T-4).....

* * * * * * *

LIST OF ILLUSTRATIONS

Figure 1. FM receiver quieting and AGC vs RSL, Bayberg, receiver A B-32

* * * * * * *

5. Link NPR vs BBL, Bayberg, receiver A, from transmitter A,..... B-33
9 . Distribution of run median RSL, receivers A and B, Bayberg..... B-34
10. Distribution of run median BBL, receive, Bayberg..... B-35
11, 12, 13 - (Same for other station.)

LIST OF TABLES

Page

Table 1. Link Parameters..... B-6
2. Equipment Parameters..... B-6
3. Summary of Link Performance..... B-9
4. Recorded Median Values..... B-10
5. Mean RSL and ICN Values..... B-10
6. Statistical Median Values Derived from Spot Measurements... B-12
7. Equipment NPR Values..... B-13
8. Antenna VSWR Values.....(Optional). B-14
9. FM Quieting Values..... B-15
10. Omitted and/or Incomplete Tests..... B-18
11. Deficiencies and Recommended Corrective Actions..... B-18

PART ONE. EVALUATION NARRATIVE

1.0 INTRODUCTION. (Short description of report content and organization including such information as the military department responsible for the link or subsystem operations and maintenance (O&M) and technical evaluation testing, and selected data as shown in tables 1 and 2.)

a. The performance of Defense Communications System (DCS) link M-0124, between Bayberg and Dachstein, Germany, was tested and evaluated in accordance with (IAW) supplement 1, DCAC 310-70-57. The US Army is responsible for the O&M of this link and for testing under the Technical Evaluation Program. The link and equipment parameters are listed in tables 1 and 2, respectively. The evaluation is based on test data collected from 1 through 16 March 1979.

Table 1. Link Parameters

STATION	PROPAGATION MODE AND LINK LENGTH	TRANSMIT FREQUENCY (MHz)	TYPE TERMINAL	DIVERSITY ORDER AND TYPE
Bayberg	LOS 43.15 km	A 8145 B 8145	TCG*	Dual space
Dachstein	26.81 mi	A 8306 B 8306	TCL*	

*Army technical control.
**Technical control.

Table 2. Equipment Parameters

STATION	RADIO	OUTPUT POWER (dBm)	MULTIPLEX	CHANNELS CAP / INSTL	ANTENNA SIZE AND TYPE
Bayberg	AN/FRC-80 (V)2	*28.5	AN/UCC-4(V)	120 / 60	12 ft parabolic
Dachstein	AN/FRC-80 (V)2	*28.5	AN/UCC-4(V)	120 / 60	12 ft parabolic

*Nominal value as stated by the manufacturer. (The same value must be included in the station data and used for performance calculations.)

b. Performance standards for this link were based on available test and acceptance (T&A) data, manufacturer's equipment specifications, calculated values, and measured performance data, as appropriate. Military standards (MIL-STD) were used only when manufacturer's specifications or other performance standards were not available. The test results are summarized in paragraphs 2.0 through 4.0. Paragraph 6.0 provides conclusions and recommendations. Link and station data are tabulated and compared with MIL-STD's where appropriate in paragraph 7.0.

1.1 DATES OF EVALUATION. 1 through 16 March 1979.

1.2 O&M AGENCY MAILING ADDRESS.

(Team chief will provide the appropriate O&M agency and correct mailing address of the unit operating and maintaining the site.)

1.3 USACC TECHNICAL EVALUATION PERSONNEL.

a. Test Team Composition. (If the same test team evaluates both sites, only one listing is given.)

(1) Bayberg

Name	Rank/Grade	Position
Floyd W. Merryvale	SFC	Team Chief
Ronald S. Bang	SSG	Technician
Fred D. Witten	SSG	Technician

(2) Dachstein

Name	Rank/Grade	Position
Raymond D. Toole	CPT	Team Chief
Wesley Hurdle	SFC	Team NCOIC
Walt B. Calandra	SSG	Technician
Leo L. Burns	SP6	Technician

b. USACC QATD Point of Contact. Chief, Operations; AUTOVON 879-2692/5588.

1.4 KEY PERSONNEL CONTACTED.

Name	Rank/Grade	Position
Edward A. Nelson	COL	CDR
David S. Willey	CPT	CDR, Communication Detachment
Joe M. Groppono	SGM	Station NCOIC, Bayberg
Otto M. Eastwood	CIV	Station Engineer, Bayberg
Tom T. Hall	SFC	Station NCOIC, Dachstein

1.5 REFERENCES. (List of documents referenced in part one.) (Prepared by Quality Assurance and Testing Detachment (QATD) personnel.)

a. DCAC 310-70-57, Supplement 1, Technical Evaluation Line-of-Sight (LOS) and Tropospheric Scatter Links.

b. DCAC 310-70-57, Supplement 4, Performance Monitoring.

c. MIL-STD-721B, Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety.

d. MIL-STD-188-313, Subsystem Design and Engineering Standards and Equipment Technical Design Standards for Long-Haul Communications Transversing Microwave LOS Radio and Tropospheric Scatter Radio.

e. TM 11-5805-507-15/1, Multiplexer Set AN/UCC-4 (V).

f. TM 11-5820-785-12, Operator's and Organizational Maintenance Manual: Radio Sets AN/FRC-80(V).

g. Manufacturer's Document Number 12M86842C, Equipment Specifications for AN/FRC-80(V) Radio Set.

2.0 TEST RESULTS. (The summary of test results will contain a synopsis of the major findings. Include information on number of channels presently installed, design number of channels used in path performance calculations, baseband loading (BBL), summaries of received signal level (RSL) and median noise power ratio (NPR).)

2.1 SUMMARY. This link is currently configured for the transmission of 60 voice channels of which 24 channels are in use. Path performance calculations and the evaluation in this report are based on 120-channel operation. A summary of measured and predicted RSL and median NPR for this link is given in table 3.

(Appropriate information will be included. In this particular case, the following statement applies.)

The measurements were taken from high frequency (HF) patch to HF patch.

(In summarizing the results of each test sequence, the measured results are to be compared to manufacturer's specifications, T&A data, and MIL-STD's as applicable. The order for citing equipment deficiencies will be manufacturer's specifications, T&A data, and MIL-STD's. In citing link or path deficiencies, the standards in order of precedence are T&A data, manufacturer's specifications, and MIL-STD's.) To the maximum extent, a comparison will be made to determine:

- If the equipment meets its design capability.

- If it meets MIL-STD requirements or the level at which it was accepted into the DCS.
- If it is being maintained and operated at, or better than, manufacturer's specifications.
- If it is meeting the engineered level and T&A results.
- If the system meets calculated values and if not, why not.

Table 3. Summary of Link Performance

PARAMETER	CALCULATED VALUE	MIL-STD* MEDIAN NOISE OBJECTIVE	MEASURED	
			Bayberg	Dachstein
RSL (dBm)	-33	NA	A -34.0 B -34.5	A -36.0 B -32.0
A PATH	NPR (dB)	NPR (dB)	NPR/BNR (dB)	NPR/BNR (dB)
70 kHz			58/61	50/56
534 kHz			59/62	51/56
1002 kHz	54.4	54.6	56/60	54/55
B PATH	NPR (dB)	NPR (dB)	NPR/BNR (dB)	NPR/BNR (dB)
70 kHz			59/56	58/63
534 kHz			60/57	56/62
1002 kHz	54.4	54.6	60/61	52/65
Combined	NPR (dB)	NPR (dB)	NPR/BNR (dB)	NPR/BNR (dB)
70 kHz			61/60	49/63
534 kHz			62/62	49/61
1002 kHz	56.9	57.1	61/61	49/64

*The NPR value was derived using the median noise allowed, paragraph 4.1.2.1.1.1a, page 7, MIL-STD-188-313.

2.2 MULTIPLE PARAMETER DATA RECORDINGS (T-1).

a. Stripchart recordings were made of RSL, received BBL, and idle channel noise (ICN). The median values extracted from the recordings are shown in table 4. The RSL values were normalized for a +28.5 dBm transmitter output. Calculated values are provided for comparison purposes.

Table 4. Recorded Median Values

PARAMETER	CALCULATED VALUE	RECM PMP LEVEL	RECORDED MEDIAN	
			BAYBERG	DACHSTEIN
RSL (dBm)	-33	-34	A -32.9 B -34.0	A -34.7 B -31.6
BBL (dBm0)	*+4.5	+5	+4.6	+3.9
ICN (dBrnC0)	23.6	24	20.0	21.0
ICN (dBm0)	**-64.9	**-64.0	**-68.5	**-67.5

*IAW Suppl 4, DCAC 310-70-57.
**Measurement converted to flat value, based on theoretical difference of 1.5 dB between C-message and flat weighting.

b. The mean RSL and ICN values shown in table 5 were obtained from the USACC Performance Monitoring Program (PMP) Monthly Means Report for calendar year 1978. (This data is provided by analysts.)

Table 5. Mean RSL and ICN Values

STATION	RSL		ICN (3-kHz flat)	
	MEAN (dBm)	STD DEVN (dB)	MEAN (dBm0)	STD DEVN (dB)
Bayberg	*-35.4	1.9	-67.1	2.1
Dachstein	*-34.9	1.4	-65.6	2.3

*Not corrected for a +28.5 dBm transmitter output.

c. Recording priorities will be as follows:

RECORDING CHANNELS AVAILABLE	RSL		LOS	ICN CHANNEL		TRANSHORIZON RSL					ICN
	A	B	BBL	1	2	A1	A2	B1	B2	BBL	CHAN 1
2	X	X	Y	Y		X	Y	X	Y	Z	Z
3	X	X/Y	Y	X/Y		X	Y	X	Y	Y	X
4	X	X	X	X		X/Y	X	X/Y	X	Y	Y
5	X	X	X	X	X	X/Y	X	X/Y	X/Y	Y	X/Y
6	*					X	X	X	X	X	X
7						*					
8											

X = 1st run; Y = 2d run; Z = 3d run.
*Record test tone stability if adequate channels are available.

2.3 AUDIO TESTS. (Significant test results will be discussed in sub-paragraphs. Discuss any audio tests that failed specifications or those that indicate significant problem areas.)

2.3.1 IDLE CHANNEL NOISE (T-8).

a. The standard for ICN was derived using the noise sources tabulated in table 1-2, paragraph 4.1.2.1.1, page 6, MIL-STD-188-313 and multiplex noise contributions in TM 11-5805-507-15/1 (TO 31W1-2UCC4-2). Individual noise sources are as follows:

(1) Radio Link Noise.

Thermal, path, and residual noise (C-msg weighted)	4.2 pWc0
Radio equipment intermodulation noise (C-msg weighted)	85.1 pWc0
Feeder echo intermodulation noise	17.4 pWc0
Interference noise	0.0 pWc0
Total single path radio noise	106.7 pWc0

(2) Multiplex Noise.

One set of channel bank equipment	44.1 pWc0
One set of group bank equipment	63.0 pWc0
One set of supergroup bank equipment	63.0 pWc0
Total multiplex noise	170.1 pWc0

b. The sum of the total single path radio noise and the multiplex noise gives a single path ICN of 276.8 pWc0 which equates to 24.4 dBrnC0. Considering the 2.5-dB reduction in radio noise due to the combiner action, the link worst case ICN is reduced to 230.1 pWc0 which is equated to 23.6 dBrnC0.

c. The median ICN values in both 3-kHz flat and C-message weighting are shown in table 6. The ICN values were statistically derived from spot measurements taken on all channels evaluated.

Table 6. Statistical Median Values Derived from Spot Measurements

STATION	MEDIAN ICN	
	FLAT (dBrn0)	C-MSG (dBrnc0)
Bayberg	23.9	17.7
Dachstein	31.9	15.1

d. The difference in noise readings between C-message and 3-kHz flat weighted measurements at Bayberg was in excess of 6 dB, and at Dachstein, the difference was almost 16 dB. This disparity indicates that spurious noise existed outside the voice telephone bandwidth on the system, especially at Dachstein. This excessive noise is considered inconsequential to the voice circuit subscribers, but may have an adverse affect on data circuit operation. The theoretical difference between the two weighting measurements should be approximately 1.5 dB. Therefore, 50-Hz components may be influencing the flat weighted measurements which may be attributed to ground loops within the stations, ineffective grounding, or a combination of both.

2.4 RADIO TESTS. (Discuss those test results in which established standards were not met and those that indicate degradation to the system/link.)

2.4.1 RADIO EQUIPMENT NOISE POWER RATIO (T-22).

a. Paragraph 3.7, sheet 9, manufacturer's document No. 12M86842C, states that the back-to-back equipment NPR measured in the worst 3.2-kHz slot in the baseband, with a noise loading of -10 + 10 log N dBm0 when N equals the number of channels, shall be 58 dB (with 10-MHz intermediate frequency (IF) for 120 channels. The RSL shall be -30 dBm and the per channel root mean square (RMS) deviation shall be 140 kHz.

b. The equipment NPR's at a military loading of +10.8 dBm0 are shown in table 7.

Table 7. Equipment NPR Values

STATION	SLOT (kHz)	NPR (dB) A XMT-RCV	NPR (dB) B XMT-RCV
Bayberg	70	53.0	49.0
	270	54.0	51.0
	534	55.0	52.0
Dachstein	70	55.0	48.0
	270	56.0	47.0
	574	54.5	46.0

c. All equipment NPR's at both stations are substandard. At Bayberg, the equipment NPR peaked at +8 dBm0 for the A path and at +6 dBm0 for the B path. At Dachstein, the equipment NPR peaked at +12 dBm0 for the A path and at +8.5 for the B path.

2.4.2 RADIO LINK NOISE POWER RATIO (T-23).

a. The NPR standard at which this link was evaluated was calculated using radio link noise tabulated according to paragraph 4.1.2.1.1, page 7, MIL-STD-188-313. The noise contributions used in the calculations are tabulated below.

Thermal noise including path noise and residual radio equipment noise	4.2 pWc0
Radio equipment intermodulation noise	85.1 pWc0
Feeder echo intermodulation noise	17.4 pWc0
Interference noise	0.0 pWc0
Total single path radio noise	106.7 pWc0

b. The total radio link noise of 106.7 pWc0 equates to an NPR of 53.5 dB at a military loading of +10.8 dBm0 and a per channel deviation of 140 kHz. This is the single path NPR for the worst slot. Considering a 2.5-dB reduction in noise resulting from the use of a combiner, the total radio noise is reduced to 60 pWc0 and the combiner output NPR is increased to 56 dB. The test results indicated that both receivers at Bayberg met the calculated objectives. At Dachstein, the most significant discrepancy was the degraded NPR's in the combined mode. Diagnostic testing of the combiner indicated defective resistive components within the combiner.

2.4.3 TRANSMITTER RADIO FREQUENCY (RF) POWER OUTPUT AND ANTENNA SYSTEM REFLECTED POWER (T-30).

a. The manufacturer's specification for the AN/FRC-80, paragraph 1.5, page 1-2, TM 11-5820-785-12, is 288.5 dBm or greater. Only transmitter A at Dachstein passed; the other failed by 1.3 dB or less.

b. The voltage standing wave ratio (VSWR) specifications looking toward the equipment are listed in sheets 8 and 9 of manufacturer's document No. 12M86842C, which state that the VSWR at the transmit frequency looking toward the transmitter shall not exceed 1.05:1. The VSWR at Dachstein met the design objective while the VSWR at Bayberg failed. Table 8 summarizes both the antenna and equipment return loss measurements and the corresponding VSWR values.

Table 8. Antenna VSWR Values

STATION	ANTENNA VSWR/RETURN LOSS (dB)	EQUIPMENT VSWR/RETURN LOSS (dB)
Bayberg	1.170/22.1	1.066/30
Dachstein	1.02/39.6	1.106/26

2.4.4 RECEIVER FM QUIETING, AUTOMATIC GAIN CONTROL (AGC)/IF, AND DIRECT CURRENT (DC) CONTROL VOLTAGE CHARACTERISTICS (T-34).

a. Paragraph 3.3.4, sheet 7, manufacturer's document No. 12M86842C, states that the minimum radio signal level required to produce an equivalent combined noise level not exceeding 52 dBm0 (30 dB signal-to-noise (S/N)) in the worst voice channel is -81 dBm or better for 120-channel operation. The above RSL's are for a diversity system with 140 kHz per channel RMS deviation.

b. The receiver frequency modulated (FM) quieting levels in the 534-kHz slot are tabulated in table 9. Both the A and B IF filters at Bayberg have approximately a 26-MHz bandpass. These units should be replaced with option C (10 MHz) IF filters to comply with design objectives. If the narrower filters are installed, the FM thresholds should be better than -79 dBm on both receivers.

Table 9. FM Quieting Values

STATION	RECEIVER	FM QUIETING LEVEL (dBm)
Bayberg	A	*-75.0
	B	*-75.0
Dachstein	A	-85.5
	B	-83.0

*Actual quieting level measured with the 26-MHz IF filters installed.

2.4.5 RECEIVER NOISE FIGURE (T-36).

a. Paragraph 3.3.6, sheet 8, manufacturer's document No. 12M86842C, states that the receiver noise figure for space diversity is 12 dB.

b. At Bayberg, receiver B failed to meet the design objective by 1 dB.

2.4.6 RECEIVER IF AMPLIFIER AND DISCRIMINATOR CHARACTERISTICS (T-39).

a. Paragraph 3.3.5, sheets 7 and 8, manufacturer's document No. 12M86842C, states that the center value of the IF shall be 70 ±0.5 MHz. The main IF bandwidth shall be nominally 100 MHz without the front end lumped constant filter. The filter shall be 10 MHz for 120-channel operation at the 3-dB point.

b. At Bayberg, both receivers had a 26-MHz measured bandwidth. The IF filters should be changed to option C (10 MHz). At Dachstein, both receivers had over 11 MHz bandwidth; they should be alined to a 10-MHz bandwidth.

2.5 TESTS THAT MET SPECIFICATIONS. The following tests were performed and met applicable standards.

a. 1-kHz Test Tone Signal Levels (T-4).

b. Idle Channel Noise (T-8).

c. Idle Channel Impulse Noise (T-9).

d. Voice Channel Frequency Response, Automatic Sweep (T-11).

e. Voice Channel Envelope Delay Distortion, Automatic Sweep (T-13).

f. Voice Channel Harmonic Distortion (T-14).

g. Voice Channel Frequency Translation (T-15).

h. Voice Channel Spurious Phase Jitter and Hits, Meter Method (T-16).

i. Voice Channel Crosstalk (T-18).

j. Transmitter-Receiver Baseband Frequency Response (T-24).

k. Transmitter RF Carrier Frequency Accuracy (T-27).

l. Transmitter Automatic Frequency Control (AFC) Characteristics (T-28).

m. Transmitter Modulator Frequency Deviation and Linearity (T-29).

n. RF Preamplifier and Preselector Bandwidth and Power Gain or Loss (T-35).

o. Receiver AFC Characteristics (T-38).

2.6 MISCELLANEOUS OBSERVATIONS. This will be the last paragraph in the equipment/system test summary and may contain the following:

a. Status of Onsite Test, Measurment, and Diagnostic Equipment (TMDE). This is a required entry. Data will be gathered on USACC Form 541-R and the results will be summarized in this paragraph. Minimum essential data to be entered on USACC Form 541-R are as follows:

(1) Item nomenclature.

(2) Model number (manufacturer's or Joint Army Navy (JAN)).

(3) Quantity authorized

(4) Quantity on hand.

(5) Items deadlined, date of deadline, work order number, supporting maintenance unit, and date of last followup action.

(6) Designate nonpreferred items list (PIL) items with the recommended PIL replacement.

(7) Items required but not authorized or on hand. Indicate the specific tests that required the TMDE and the authorizing document.

b. Status of Onsite Prescribed Load List (PLL). The list will include:

(1) Quantity authorized to be stocked.

(2) Number at zero balance.

(3) Effect that nonavailability has on equipment/system performance.

c. Deadlined Onsite Equipment. Explain which equipment is deadlined and the impact it will have on the DCS.

d. Records and Operations. Summarize the results of site record keeping and operation as determined from the completion of the checklist.

e. Comments. Other comments considered appropriate by the team chiefs.

3.0 EQUIPMENT PERFORMANCE INDICATORS. From the measured data, the performance of the major equipment is depicted in the following figures.

(Figures for paragraph 3.0 and 4.0 will include figures similar to those shown in this sample report.)

Figure 1. FM receiver quieting and AGC vs RSL, Bayberg, receiver A.

* * * * * * *

3. FM receiver quieting and AGC vs RSL, Dachstein, receiver A. (Not included in sample.)

4.0 TRANSMISSION QUALITY INDICATORS. From the reduced data, the transmission quality as determined from each end of the link is depicted in the following figures.

* * * * * * *

Figure 5. Link NPR vs BBL, Bayberg, receiver A from transmitter A

(Distribution of run median RSL from each link.)

(Distribution of run median BBL, each link.)

(Other figures considered pertinent by the analysts.)

5.0 OMITTED AND/OR INCOMPLETE TESTS. The tests listed in table 10 were not performed or were performed in such a way as to yield incomplete or invalid data.

(List all required tests that were omitted, incomplete, or yielded invalid results. A concise explanation for the tests listed in this table will be shown in the comments portion of the table.)

Table 10. Omitted and/or Incomplete Tests

STATION	TEST	REMARKS
Bayberg	NPR and BNR of FDM (T-40)	No TMDE
Both	REceiver local Oscillator Frequency Accuracy (T-37)	No test point available

6.0 CONCLUSIONS AND RECOMMENDATIONS. Analysis of the data measured during this evaluation and comparison with referenced standards indicate that this link was providing satisfactory service. Correction of the deficiencies listed in table 11 will increase the reliability of link performance. Minor deviations that are not presently causing significant actions are listed in the nonreportable section. However, these discrepancies should be periodically monitored by the O&M command until such time that appropriate corrective measures are accomplished.

Table 11. Deficiencies and Recommended Corrective Actions

DEFICIENCY	REF	RECOMMENDED CORRECTIVE ACTION
REPORTABLE		
(List significant deficiencies that could cause system degradation and require corrective action to bring the equipment within specification. The reference column refers to the paragraph in the final report that presented the discussion of the deficiency. Recommended corrective actions should be listed.)		
NONREPORTABLE		
(The nonreportable deficiencies are minor deficiencies that do not appear to be causing system degradation. Recommended corrective actions should also be listed.)		

(These deficiencies do not need to be presented to the detachment in table format.)

7.0 DATA TABULATION. Link and station data are tabulated on the following pages.

(Link and station data should be presented as listed in the contents page and on the forms shown in this sample. Forms may be handwritten but should be legible and the data must be accurate.)

7.1 LINK DATA TABULATION - LOS

LINK DATA TABULATION - LOS (CCR 702-1-3)		STATION FROM	STATION TO
		BAYBERG	DACHSTEIN
1.	DCS Link Number	M-0124	
2.	DCA Area	GERMANY	
3.	TEP Testing MILDEP	US ARMY	
4.	Test Period	1-6 MARCH 1979	
5.	Operating MILDEP	US ARMY	
6.	Path Length (smi/km/nm)	26.81/43.15/23.30	
7.	Diversity:		
	a. Order	DUAL	
	b. Type	SPACE	
8.	Transmitter Output Power (watts)	28.5	
9	Path Antenna Gain (dB)	94.94	
10.	Transmission Line & Miscellaneous Loss (dB)	12.43	
11.	Path Transmission Loss (dB)	144.0	
12.	Calculated Median RSL (dBm)	-333	
13.	Measured Receive Signal Level (dBm):		
	a. Receiver A		
	(1) Exceeded 10% of Time	-23.5	-35.0
	(2) Exceeded 50% of Time	-34.0	-36.0
	(3) Exceeded 90% of Time	-35.5	-37.5

	BAYBERG		DACHSTEIN
b. Receiver B			
(1) Exceeded 10% of Time	-33		DNA
(2) Exceeded 50% of Time	-34.5		-32.4*
(3) Exceeded 90% of Time	-38		DNA
c. Recommended PMP Level (Suppl 4, DCAC 310-70-57)		-34	
14. Fade Margin (Difference between Median RSL and RSL at FM Improvement Threshold (dB):			
a. Value from Path Loss Calculation (dB)		48	
b. Measured:			
(1) Receiver A	41		49.5
(2) Receiver B	40.5		51.0
15. Link NPR/BNR (dB) at +10.8 dBm0 Loading:			
a. Measured (Tx No A Rx No A):			
(1) Low 70 (kHz)	58		50
(2) Mid 270 (kHz)	59		51
(3) High 534 (kHz)	56		52
(4) Median RSL During Test (dBm)	-34.5		-37.5
b. Measured (Tx No B Rx No B):			
(1) Low 70 (kHz)	59		58
(2) Mid 270 (kHz)	60		56

*Estimated from spot measurements

	BAYBERG	DACHSTEIN
(3) High 534 (kHz)	60	52
(4) Median RSL During Test (dBm)	-34.0	-32.0
c. Combined:		
(1) Low 70 (kHz)	61	49
(2) Mid 270 (kHz)	62	49
(3) High 534 (kHz)	61	49
(4) Median RSL During Test (dBm) (Best Receiver)	-34.0	-32.0
16. Voice Channel Noise (dBrnC0):		
a. DCA Standard	-24.5	
b. Measured (from recorded data):		
(1) Exceeded 10% of Time	24.5	28.0
(2) Exceeded 50% of Time	20.0	22.5
(3) Exceeded 90% of Time	18.6	21.5
17. Impulse Noise (for 8 - hour period) (Counts):		
a. Measured (CH___GP___SG___):		
(1) Low _____ dBrnC0	DNA	
(2) Mid _____ dBrnC0		
(3) High _____ dBrnC0		
b. Measured (CH___GP___SG___):		
(1) Low _____ dBrnC0		

	BAYBERG	DACHSTEIN
(2) Mid _____ dBrnC0		
(3) High _____ dBrnC0		
c. Measured (CH___GP___SG___):		
(1) Low _____ dBrnC0	DNA	
(2) Mid _____ dBrnC0		
(3) High _____ dBrnC0		
18. Baseband Loading:		
a. Calculated (see Suppl 4, DCAC 310-70-57)	+4.5	
b. Exceeded 10% of Time	+1.5	+1.5
c. Exceeded 50% of Time (median) ...	-5.6	-7.0
d. Recommended PMP Level	+5	

7.1.1 LINE-OF-SIGHT WORKSHEET

LINE OF SIGHT WORKSHEET (CCR 702-1-3)			TEST ENGINEERS SIGNATURE
OCS LINK NO. M-0124	STATIONS UNDER TEST Bayberg TO Dachstein		
DEFINITION	**SYMBOL**	**VALUE**	**REFERENCE/EQUATION**
Path distance	d	43.15 km	
Height of transmit antenna above sea level	h_{ts}	0.568 km	
Height of receive antenna above sea level	h_{rs}	0.721 km	
Surface refractivity reduced to sea level	N_o	310	Figure 4.1 (page 4-3)
Average value of N at the earth surface	N_s	300	Page 4-1
Effective earth radius	a	9200 km	Equation 4.4 or Figure 4.2
Effective height of transmit antenna above ground	h_1	NA km	Page 5-8
Effective height of receive antenna above ground	h_2	NA km	Page 5-8
Carrier frequency	f	8306 MHz	
Loss relative to free space	A	0 dB	Section 5
Atmospheric absorption	A_a	0.5 dB	Section 3 and Figure 3.6
Basic median transmission loss	L_b	144.04 dB	20 log d + 20 log f + 32.45 + A + A_a
Effective distance	d_e	156.08 km	Page 10-8
Type climate		1 #	Page 10-6 and 10-7
Correction factor	$V(0.5,d_e)$	0 dB	Figure 10.13 (page 10-26)
Predicted median long term transmission loss	$L_n(0.5)$	144.04 dB	L_b - $V(0.5,d_e)$
Long term varibility for 99.99% of all hours	Y(0.9999)	-5.0 dB	Section 10 and III.7
Transmission loss not exceeded for 99.99% of all hours	$L_n(q)$	139.0 dB	$L_n(0.5)$ - Y(0.9999)

USACC FORM 504-R
1 JUL 78 EDITION OF 1 OCT 77 IS OBSOLETE

7.1.2 LINK NOISE PERFORMANCE WORKSHEET

LINK NOISE PERFORMANCE WORKSHEET (CCR 702-1-3)			TEST ENGINEERS SIGNATURE
DCS LINK NO. M-0124	STATIONS UNDER TEST Bayberg TO Dachstein		
DEFINITION	SYMBOL	VALUE	REFERENCE/EQUATION
Median basic transmission loss	$L_n(0.5)$	144.0 dB	From transmission loss worksheet
Transmitter power	P_t	28.5 dBm	10 log P_t (milliwatts)
Antenna diameter (transmit)	D_t	12 ft	
Antenna diameter (receive)	D_r	12 ft	
Carrier frequency	f	8306 MHz	
Free space antenna gain (transmit) relative to isotropic radiator	G_t	47.47 dB	Manufacturer's specifications or 20 log D_t + 20 log f - 52.5 dB
Free space antenna gain (receive) relative to isotropic radiator	G_r	47.47 dB	Manufacturer's specifications or 20 log D_r + 20 log f - 52.5 dB
Forward scatter multipath coupling loss	L_{gp}	0 dB	From coupling loss worksheet
Path antenna gain	G_p	94.94 dB	$G_t + G_r - L_{gp}$
Total transmission line and associated losses	L_t	12.43 dB	Manufacturer's specifications and/or measurements
Median receive carrier power	P_{rc}	-33.0 dBm	$P_t + G_p - L_n(0.5) - L_t$
Receiver noise figure	F	12 dB	Manufacturer's specifications or measurements
Receiver IF bandwidth	B	10 MHz	Manufacturer's specifications or measurements
Receiver noise power	P_{rn}	-92 dBm	10 log B + F - 114
Median carrier-to-noise ratio	C/N	59 dB	$P_{rc} - P_{rn}$
Number of VF channels	n	120	
Top baseband frequency	f_m	552 kHz	
RMS per channel deviation	d_{rms}	140 kHz	Without pre-emphasis
Pre-emphasis improvement for top channel	I_p	0 dB	

USACC FORM 497-R
1 JUL 78

Page 1
EDITION OF 1 SEP 77 (496-R and 496-1R) IS OBSOLETE

CONTINUATION — LINK NOISE PERFORMANCE WORKSHEET

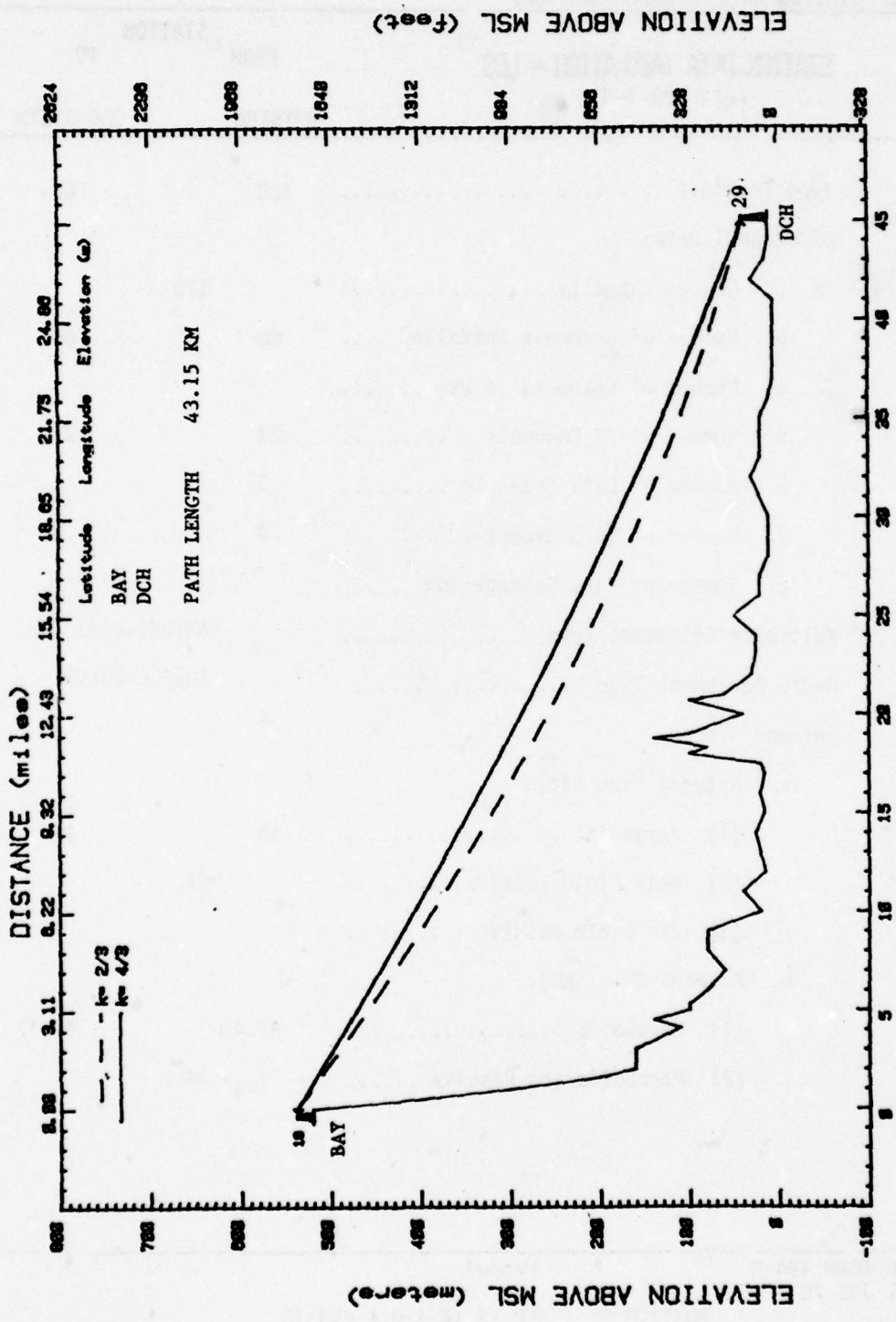
DEFINITION	SYMBOL	VALUE	REFERENCE/EQUATION
FM improvement for top channel	I_{fm}	23.2 dB	20 log d_{rms} - 20 log f_m + 10 log B + I_p + 25.1 dB
Unweighted median channel signal-to-thermal noise ratio for top channel	S/N(t)	82.2 dB	C/N + I_{fm}
C-message weighted thermal noise power	N(t)	4.2 pwCO	$Log^{-1}0.1[88.5-S/N(t)]$
Order of diversity		2	
Median diversity improvement	I_d	2.5 dB	
Combined weighted thermal noise power	N(tc)	2.3 pwCO	
Equipment noise power ratio	NPR	58 dB	DCA or manufacturer's specification
White noise loading	P_n	10.8 dBm0	-10 + 10 log n
White noise bandwidth	B_n	492 kHz	
Equivalent channel signal-to-intermodulation noise ratio	S/N(i)	69.2 dB	NPR - P_n + 10 log B_n - 4.9 dB
C-message weighted intermodulation noise power	N(i)	85.1 pwCO	$Log^{-1}0.1[88.5-S/N(i)]$
C-message weighted noise power due to feeder echo	N(fe)	17.4 pwCO	From feeder echo worksheet
C-message weighted noise power due to multipath propagation	N(mp)	0 pwCO	From path intermodulation worksheet
Total median weighted noise power	N(total)	104.8 pwCO	N(tc) + N(i) + N(fe) + N(mp)
DCA median noise allocation	N(DCA)	202 pwCO	
Design margin		2.8 dB	10 log [N(DCA)/N(total)]

ECHO DISTORTION WORKSHEET (CCR 702-1-3)				TEST ENGINEERS SIGNATURE
DCS LINK NO. M-0124	STATIONS UNDER TEST Bayberg TO Dachstein			
DEFINITION	SYMBOL	VALUE TRANSMIT STATION	VALUE RECEIVE STATION	REFERENCE/EQUATION
VSWR at point A		1.1	1.1	Manufacturer's specs or measurement
Return loss A	L_a	26.4 dB	26.4 dB	20 log $\left\|\frac{VSWR+1}{VSWR-1}\right\|$
VSWR at point B		1.1	1.1	Manufacturer's specs or measurement
Return loss B	L_b	26.4 dB	26.4 dB	20 log $\left\|\frac{VSWR+1}{VSWR-1}\right\|$
Transmission distance	D	38.1 m	65.53 m	
Attenuation constant	α	0.0836 dB/m	0.0836 dB/m	Manufacturer's data
Transmission loss A to B	L_t	3.19 dB	4.64 dB	αD
Velocity of propagation	v	207 m/μs	207 m/μs	Manufacturer's data
Echo delay	T	0.368 μs	0.633 μs	$2D/v$
RF signal-to-RF echo power ratio	S/E	59.2 dB	62.1 dB	$L_a + L_b + 2L_t$
Number of VF channels	n	120	120	
Top baseband frequency	f_m	0.552 MHz	0.552 MHz	
Per channel deviation (rms)	d_{rms}	0.14 MHz	0.14 MHz	Manufacturer's standard or measurements
Baseband white noise power	P_n	10.8 dBm0	10.8 dBm0	
White noise bandwidth	B_n	0.492 MHz	0.492 MHz	
System deviation (rms)	σ	0.486 MHz	0.486 MHz	$d_{rms} \log^{-1}(0.05P_n)$
Deviation ratio	σ/f_m	0.880	0.880	
Top baseband frequency times echo delay	f_mT	0.203	0.349	
Interference ratio	K	9.0 dB	5.5 dB	Figure 1

CONTINUATION: ECHO DISTORTION WORKSHEET

DEFINITION	SYMBOL	VALUE TRANSMIT STATION	VALUE RECEIVE STATION	REFERENCE/EQUATION
Emphasis improvement	I_p	0 dB	0 dB	3 dB for CCIR emphasis
Noise power ratio due to echo	NPR	68.2 dB	67.6 dB	S/E + K + I_p
Channel signal-to-noise ratio due to echo	S/N	79.4 dB	78.8 dB	NPR - P_n + 10 log B_n + 25.1
Channel echo noise	N_e	8.1 pWc0	9.3 pWc0	Log^{-1}[0.1 (88.5-S/N)]
Link channel echo noise		17.4 pWc0		Sum of noise powers due to echos at both stations

COMMENTS



Link Profile from Bayberg to Dachstein

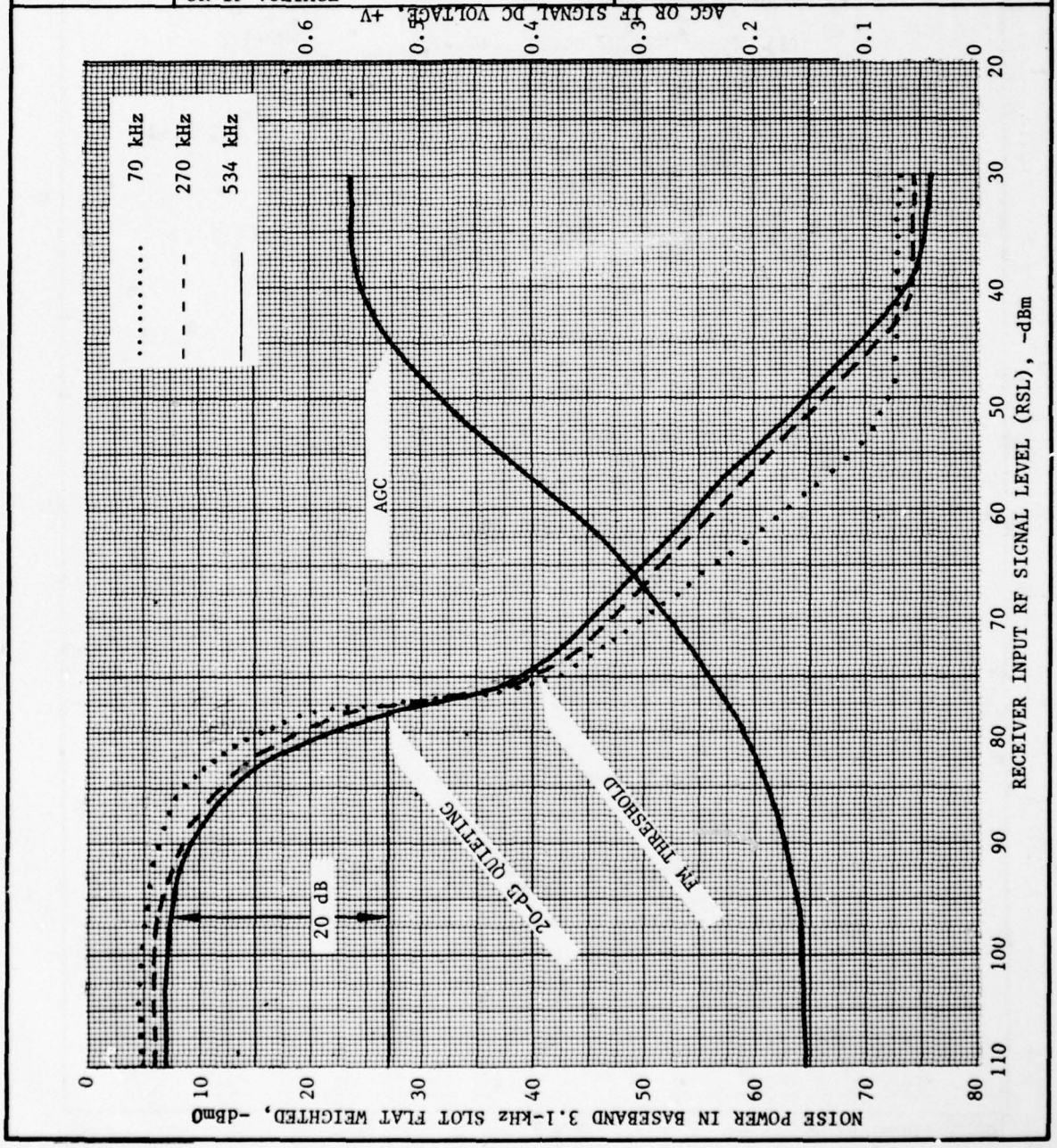
7.2 STATION DATA TABULATION - LOS

STATION DATA TABULATION - LOS (CCR 702-1-3)	STATION FROM	STATION TO
	BAYBERG	DACHSTEIN
1. Type Terminal	TCG	TCL
2. VF Channel Data:		
a. Design Capacity	120	
b. Number of Channels Installed	60	60
c. Number of Channels in Use		
d. Number of VF Channels	23	23
e. Number of Data Channels	1	1
f. Number of Thru Groups	0	0
g. Number of Thru Supergroups		
3. Multiplex Equipment Type	AN/UCC-4(V)	
4. Radio Equipment Type	AN/FRC-80(V)2	
5. Antenna System:		
a. Antenna Size (ft):		
(1) Parabolic	12	12
(2) Near Field Passive	NA	
(3) Far Field Passive		
b. Antenna Gain (dB):		
(1) Parabolic	47.47	47.47
(2) Parabolic and Passive	NA	

	BAYBERG	DACHSTEIN
(3) Far Field Passive		
c. Transmission Line:		
(1) Type (RG/WR, etc.)	WR-112	
(2) Length (meters)	38.1	65.53
(3) Loss (dB)	3.19	4.64
6. VSWR (Antenna System):		
a. DCA Standard	1.106:1	
b. Measured:		
(1) Transmit Frequency A	1.066:1	1.106:1
(2) Transmit Frequency B		
(3) Receive Frequency A		
(4) Receive Frequency B		
7. Transmitter Frequency Assignment (GHz):		
a. Transmitter A	8145	8306
b. Transmitter B	8145	8306
8. Transmitter Frequency Accuracy (%):		
a. DCA Standard	0.0018	
b. Manufacturer's Specifications ...	0.005	
c. Measured:		
(1) Transmitter A	0.00009	0.00119
(2) Transmitter B	0.00043	0.00073

CCP 702-11

GENERAL PURPOSE RF GRAPH			PAGE OF PAGES DATE	
DCS LINK NO. M-0124	STATION UNDER TEST BAYBERG	DISTANT STATION DACHSTEIN	ENGR. INIT.	TECHN. INIT.
TEST NO. T - 34	TEST TITLE FM RECEIVER NOISE QUIETING AND AGC OR IF VOLTAGE	EQUIPMENT MOTOROLA AN/FRC-80(V2) SUBASSEMBLY RECEIVER A		



DD FORM 2100
1 SEP 77

Figure 1. FM receiver quieting and AGC vs RSL, Bayberg, receiver A.

GENERAL PURPOSE GRAPH PAPER DATA SHEET G-10			PAGE_____ OF _____ PAGES DATE(day,mo.,year)
DCS LINK NO. M-0124	STATION UNDER TEST BAYBERG	DISTANT STATION DACHSTEIN	TEST ENGR. SIGNATURE
TITLE OF PERFORMANCE PLOTTED LINK NPR VS BBL FROM TRANSMITTER A			TEST NO.

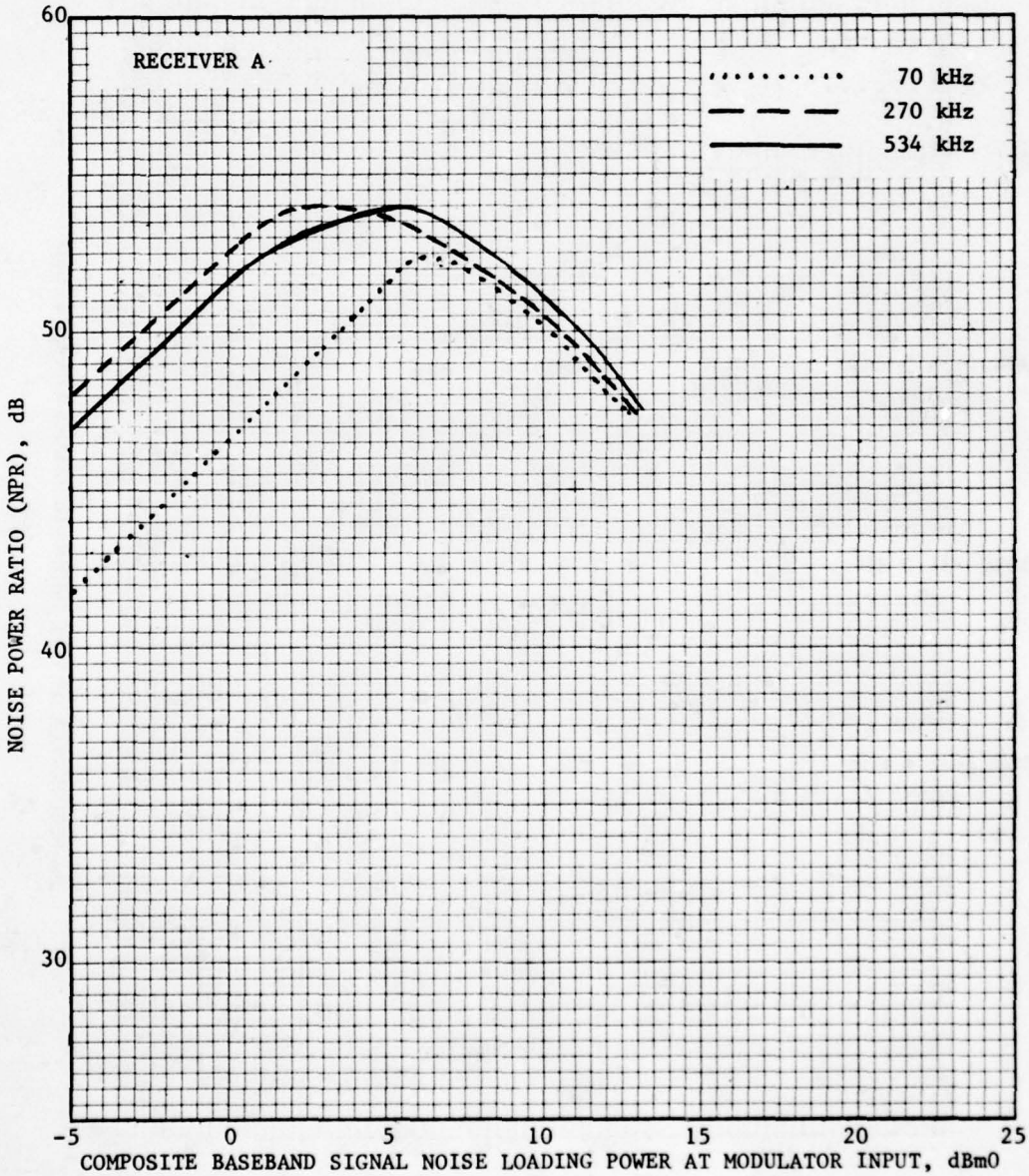


Figure 5. Link NPR vs BBL, Bayberg, receiver A from transmitter A.

DISTRIBUTIONS OF RUN MEDIAN RSL AND V.CH. NOISE

PAGE _____ OF _____ PAGES

DATE (day, mo., year)

DATA SHEET T1-14

DCS LINK NO.	STATION UNDER TEST	RUN NUMBERS	TEST ENGR. SIGNATURE
M-0124	BAYBERG	FROM: 1 THRU: 187	

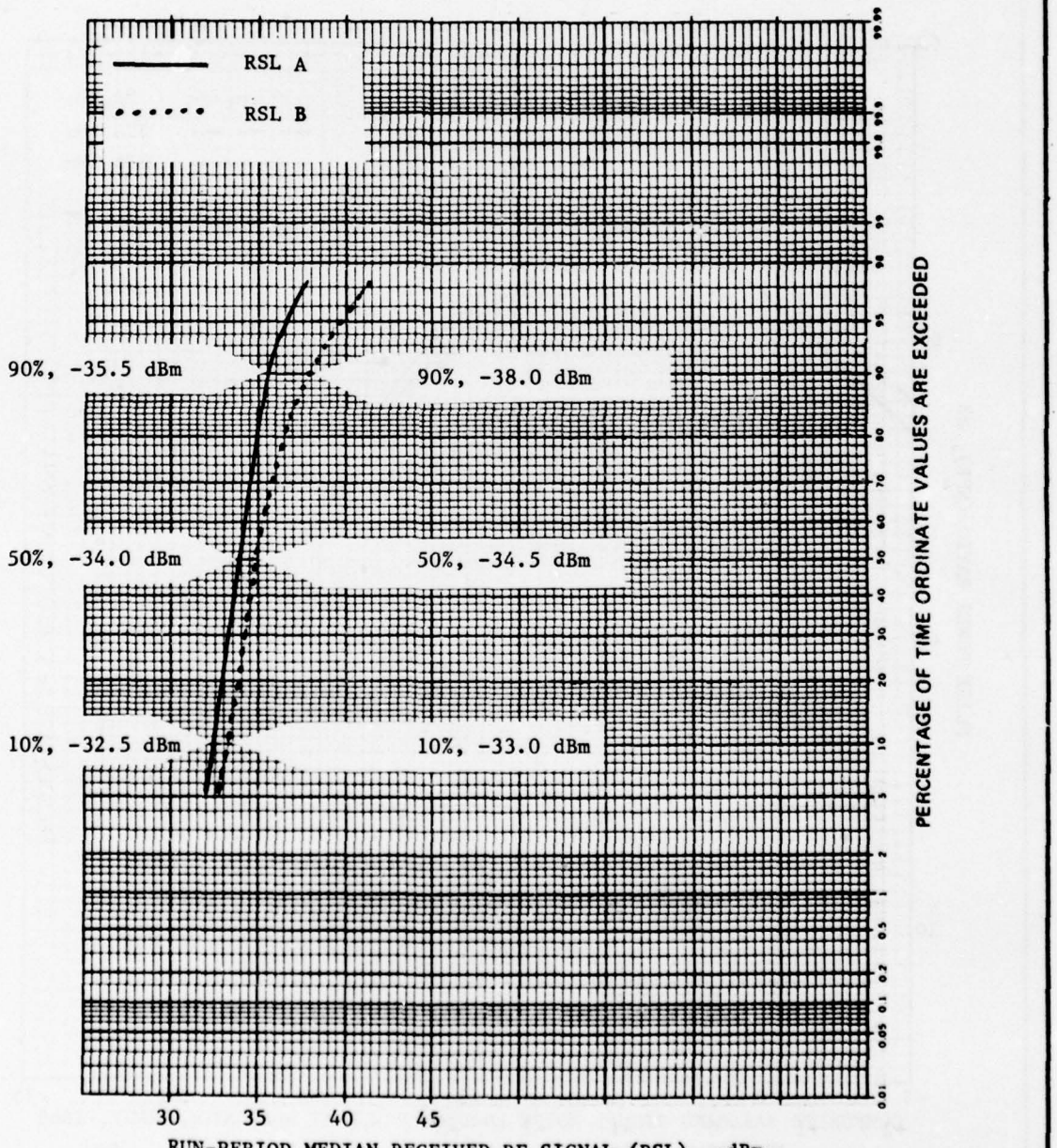


Figure 9. Distribution of run median RSL, rcvrs A & B, Bayberg.

DCA FORM (TEST) MAR 73 T1-14

DISTRIBUTIONS OF RUN MEDIAN BBL			PAGE _____ OF _____ PAGES
DATA SHEET T1-14			DATE (day, mo., year)
DCS LINK NO.	STATION UNDER TEST	RUN NUMBERS FROM: 1 THRU: 114	TEST ENGR. SIGNATURE
M-0124	BAYBERG		

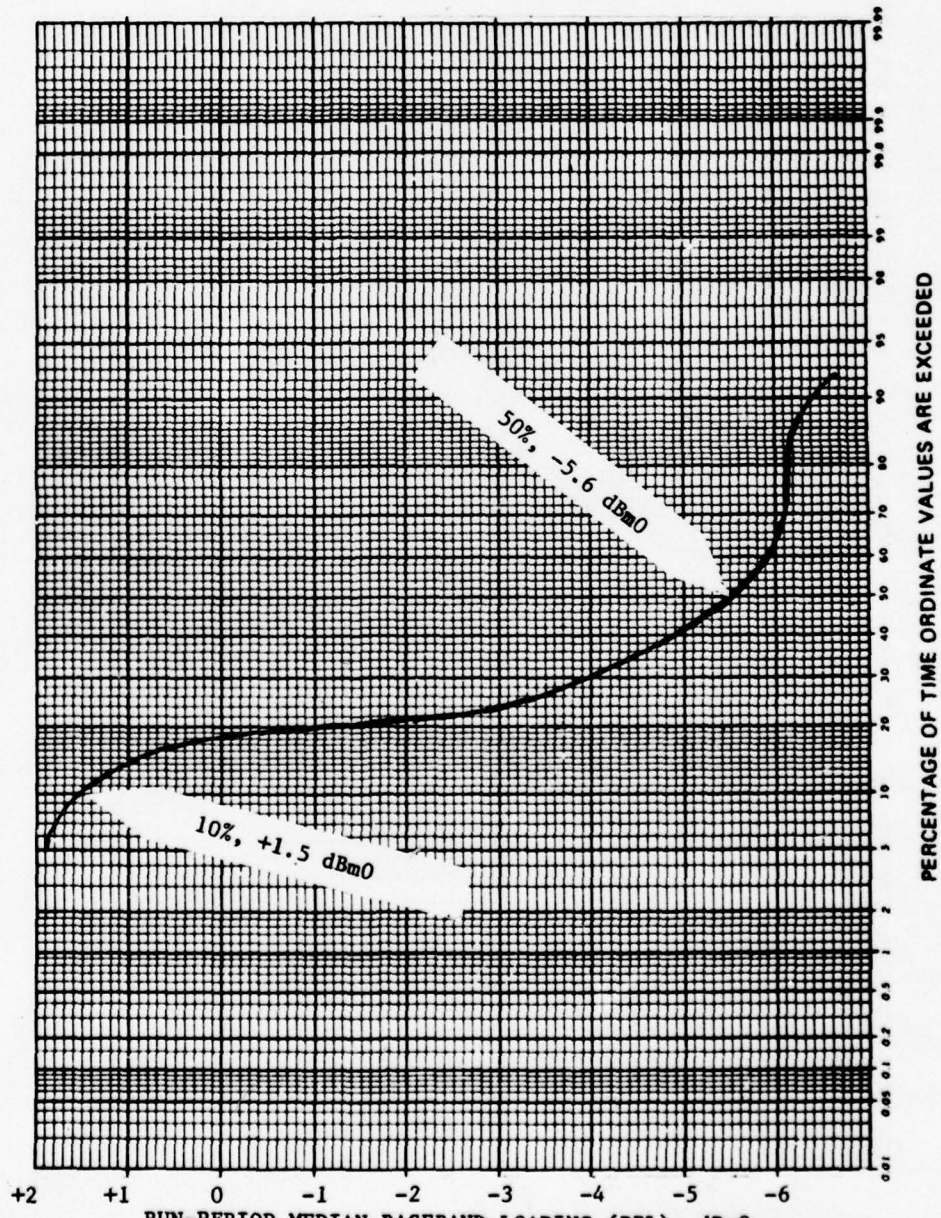


Figure 10. Distribution of run median BBL, receive, Bayberg.

DCA FORM (TEST) MAR 73 T1-14

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES

CIRCUIT PARAMETERS

Characteristics	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
a. Frequency Response[1] kHz	dB								
0.3-2.7								-2 to +6	
0.3-3.0		-2 to +6	-1.5 to +4.5	-1 to +3		-3 to +8	-2 to +6	-3 to +12	
0.4-2.8					-8 to +20				
0.5-2.8		-1 to +3	-0.5 to +2	-0.5 to +1.5			-1 to +3		
0.6-2.4					-7 to +12				
1.0-2.4								-1 to +3	
0.7-2.3						-1 to +3			

[1]Loss frequency characteristics are given in terms of comparison to the measured loss at 1004 hertz. For example, in the S1 schedule the loss frequency characteristic should not exceed the range of 2 dB less loss (-) to 6 dB more loss (+) between 0.3-3.0 kHz when compared to the measured loss at 1004 hertz. This frequency is used to avoid subharmonics of the 8 kHz frequency used extensively in PCM/TDM.

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

Characteristics	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
b. Maximum Envelope Delay with reference to the minimum delay measured in the widest specified band	micro-sec								
kHz									
0.5-2.8		3000	1500	600			3000		
0.6-2.6		1500	750	300			1500		
0.8-2.6								1750	
1.0-2.4								1000	
1.0-2.6		500	250	100			500		
c. Maximum Net Loss Variation	dB	±4	±3	±2	±4	±2	±4	±4	
d. Maximum Change in Audio-frequency	Hz	±5	±5	±5	±5	±5	±5	±5	

#

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

	Characteristics	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
	e. Minimum Longitudinal Balance	dB	40	40	40	40	40	40	40	
	f. Maximum Total Peak Telegraph Distortion	%								20
#	g. Maximum Mark or Space Bias Distortion	%								5
#	h. Maximum Allowable Channel Noise[2, 3, 4]	dBrnCØ								
	0-81 kilometers (0.50 miles)		31	31	31	31	31	31	31	
	82-161 (51-100)		34	34	34	34	34	34	34	
	162-644 (101-400)		37	37	37	37	37	37	37	
	645-1609 (401-1000)		41	41	41	41	41	41	41	
	1610-2414 (1001-1500)		43	43	43	43	43	43	43	
	2415-4024 (1501-2500)		45	45	45	45	45	45	45	
	4025-6438 (2501-4000)		47	47	47	47	47	47	47	
	6439-12874 (4001-8000)		50	50	50	50	50	50	50	
	12875-25748 (8001-16000)		53	53	53	53	53	53	53	
	i. Maximum Single Tone Interference Below Circuit Noise in Each Mileage Category[4]	dB	3	3	3	3	3	3	3	

[2]D1 and D2 allowable channel noise for Government-owned circuits 47 dBrnCØ for all distances shown above.

[3]Consider a satellite channel as equivalent to a 3219 kilometer (2000-mile) landline channel in determining circuit length.

[4]For circuits operating at 7200/9600 b/s, characteristic r replaces characteristic h. Circuits equipped with PCM terminals should not exceed 47 dBrnCØ for all distances and characteristic i does not apply.

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

Characteristics	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
j. Impulse Noise Ref Level 71 dBrnCØ 72 dBrnØ voice band wtg	Max Count in 15 min above ref level	15	15	15			15	15	
k. Terminal Impedance 600 ohm[5]	% tolerance	±10	±10	±10	±10	±10	±10	±10	
l. Composite Data Transmission Level	dBmØ	-13	-13	-13	-13	-13	-13	-13	
m. Phase Jitter (peak to peak)	Degree	15	15	15			15	15	
n. Harmonic Distortion[6]	dBmØ	-40	-40	-40	-40	-40	-40	-40	

[5]For Government-owned circuits measured across the frequency band of interest. This impedance is essentially resistive.

[6]Applies to the measurement of any of the harmonics of a test frequency of 704 Hz introduced at a level of -10 dBmØ. This value equates to any harmonic 30 dB below the fundamental. For circuits operating at 7200/9600 b/s, Non-linear Distortion (characteristic s) should be substituted for this parameter.

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

Characteristics	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
o. Gain Hit[7], [10] greater than 4 milliseconds duration	Max Count in 15 min								
Gain Change 3 dB		8	8	8			8	8	
or 4 dB		6	6	6			6	6	
p. Phase Hit[8], [10] exceeding 20 degrees and lasting longer than 4 milliseconds	Max Count in 15 min exceeding threshold	8	8	8			8	8	
q. Dropout[9], [10] equal to or greater than 12 dB and exceeding a period of 10 milliseconds	Max Dropout in 15 min	2	2	2			2	2	

[7]Gain hits are sudden uncontrolled changes in the gain or loss of a channel. Changes lasting less than 4 milliseconds are classed as impulse noise.

[8]Phase hits are sudden uncontrolled changes in phase of the transmitted signal. Changes lasting less than 4 milliseconds are also classed as impulse noise.

[9]Dropouts are large reductions in channel gain.

[10]It is not intended that this parameter be measured routinely. Measurement will be made only at circuit activation and, if necessary, during unscheduled outages as a troubleshooting aid.

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

	Characteristics	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
#	r. Signal to C-Notched Noise Ratio[11, 12]	dB	28		28					
#	s. Nonlinear Distortion[11, 13]	dB								
	(1) Signal to second order distortion		35		35					
	(2) Signal to third order distortion		40		40					

[11] A frequency of 1004 Hz is introduced at -10 dBmØ.

[12] This characteristic replaces characteristic h for circuits operating at 7200 and 9600 bits/sec.

[13] This characteristic replaces characteristic n for circuits operating at 7200 and 9600 bits/sec.

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

(GROUP BANDWIDTH CHANNELS - FDM OR DATA DERIVED)

Characteristics	Unit of Meas	X1	X2
a. Pilot Frequency	kHz	104.08	104.08
b. Frequency Response kHz loss with respect to 104.08 kHz	dB		
0-100 kilometers (0-62.5 miles)		-1.3 to +1.8	-1.3 to +1.8
100-201 (62.5-125)		-2.0 to +2.9	-2.0 to +2.9
201-402 (125-250)		-2.5 to +4.0	-2.5 to +4.0
402-804 (250-500)		-2.9 to +4.0	-2.9 to +4.0
804-1609 (500-1000)		-3.3 to +4.9	-3.3 to +4.9
1609-3218 (1000-2000)		-4.4 to +4.9	-4.4 to +5.9
3218-6436 (2000-4000)		-4.4 to +6.7	-4.4 to +6.7
c. Envelope Delay Equalized parabolic curve 64-104 kHz, reference 84 kHz	micro-sec		
0-100 kilometers (0-62.5 miles)			-9.0 to +3.2
100-201 (62.5-125)			-9.4 to +5.8
201-402 (125-250)			-9.7 to +8.0
402-804 (250-500)			-9.9 to +8.5
804-1609 (500-1000)			-10.1 to +10.5
1609-3218 (1000-2000)			-10.7 to +13.6
3218-6436 (2000-4000)			-10.9 to +14.9
Unequalized, typical points on curve			
Measured at 60 kHz		3000	
Measured at 64 kHz		300	
Measured at 108 kHz		2800	

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

Characteristics	Unit of Meas	X1	X2
d. Amplitude Stability			
Short Term	dB	±.5	±.5
Long Term		±1.0	±1.0
e. Maximum Frequency Offset	Hz	±2	±2
f. Impedance Balanced (preferred)		135	135
Unbalanced	ohm	75	75
g. Return Loss, minimum over frequency range 60-108 kHz	dB	25	25
h. Interface Transmission Level Point (assuming Government-furnished interconnect filters)	dBm		
Sending to Facility		-34.5	-5 to -42
Receiving from Facility		-12.0	-5 to -42
i. Phase Jitter, Peak to Peak	Degree	15	15

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

Characteristics	Unit of Meas	X1	X2
j. Random Noise unweighted	dBmØ		
0-804 kilometers (0-500 miles)		-38	-38
804-1609 (500-1000)		-35	-35
1609-3218 (1000-2000)		-32	-32
3218-6436 (2000-4000)		-29	-29
k. Impulse Noise, Flat Weighting 15-minute measurement at -10 dBmØ	Maximum Count	175	175
l. Spurious Tone Level, worst case (96 kHz)	dBmØ	-27	-27
m. Average (30-second) Long Term Power in 60-108 kHz band, maximum permissible	dBmØ	-5	-5
n. Instantaneous Peak Power maximum permissible	dBmØ	+17	+17
o. Maximum Out-of-Band (60-108 kHz) Power	dBmØ	-5	-5

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS (CON.)

Characteristics	Unit of Meas	X1	X2
p. Maximum Operating Signal Power permitted in any 4-kHz subchannel. Total number of active channels must be such that characteristic m is not violated.	dBmØ	-13	-13
q. Maximum Test Tone Power Level in any 4-kHz subchannel	dBmØ		
Test duration less than 5 minutes		-13	-13
Test duration more than 5 minutes		-16	-16
r. Maximum Permissible Energy in vicinity of pilot 104.08 kHz	dBmØ		
±10 Hz		-20	-20
+10 to +50 Hz and -10 to -50 Hz		-35	-35
+50 to +110 Hz and -50 to -110 Hz		-30	-30
s. Out-of-Band Power Density/4-kHz Band	dBmØ	-13	-13

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS Y1

Characteristic	Unit of Measure	Circuit Parameter Y1
Data Rate	Megabits per second	1.544 +150 b/s -300 b/s
Data Signal Level Normal Modulation Scheme - Bipolar RZ, AMI[14] logic one logic zero Optional Modulation Scheme - NRZ[15] logic one logic zero	d.c. Volt	 $+3 \pm .5$ $0 \pm .005$ $+3 \pm .5$ $-3 \pm .5$
Impedance Normal Bipolar - Unbalanced Optional NRZ - Unbalanced	Ohm	 100 75
Average Bit Error[16] Rate (BER) over worst 30-minute interval - Maximum allowable	Ratio of errored bits to total transmitted bits	$.54 \times 10^{-10}$ L_1* 1.45×10^{-10} L_2**

[14]Return to zero, alternate mark inversion (RZ, AMI).

[15]Nonreturn to zero (NRZ).

[16]For circuits that are not to be extended (i.e., direct user-to-user 1.544 Mb/s circuits), the BER requirement is 1×10^{-7} and the availability is 99 percent.

*L_1 = length in km.

**L_2 = length in mi.

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

CIRCUIT PARAMETERS Y1

Characteristic	Unit of Measure	Circuit Parameter Y1
Circuit Availability Requirement	Percentage of time that circuit was in (excluding the time the circuit failed to meet the BER requirement) to the <u>total</u> time considered	$1 - (2.7 \times 10^{-7} \times L_1)$* $1 - (7.24 \times 10^{-7} \times L_2)$**

*See footnote *, page 19.
** See footnote **, page 19.

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

Z1, Z2, Z3 TECHNICAL SCHEDULES

(Z1 through Z3 technical schedules establish the parameters for full-duplex 50 kbps transmission media within the bandwidth of 0.1 to 50 kHz terminated in a nominal 135 ohms.

Z1 Parameter is for a local circuit used to interconnect two KY-3 terminals over physical metallic nonloaded cable pairs.

Z2 Parameter is for a local circuit used to interconnect a KY-3 to a switchboard over metallic facilities as in Z1 but since the switchboard provides no equalization, all equalization on the cable pair transmitting toward the switchboard must be "equipped by the line."

Z3 Parameter is for a local circuit used between two switchboards where no equalization capability exists at either end. This circuit must be essentially flat over the required frequency range and low net loss. Repeater amplifier equalizers are usually required on these circuits.)

Characteristic	Unit of Measure	Z1 Both Directions	Z2 Sub to Switch	Z2 Switch to Sub	Z3 Both Directions
1. Low-Frequency Noise	dBm	<-36	<-36	<-36	<-36
2. S+N/N	db	>20	>33	>26	>36
3. Impulse Noise	1 peak per second exceeding stated threshold in dB below received S+N level	12	25	18	28
4. Net Loss Variation	dB	±2	+2	±2	±2
5. Lineup Loss (kHz)	dB loss of				
0.1	OdBm	+10		+3	
1.0	transmitted	+9		+3	
3.0	tone	+11		+5	
5.5		+14		+8	
10.0		+19		+13	
18.0		+26		+20	
25.0		+30		+24	
32.0		+31		+25	
50.0		+36		+28	
.1 to 50.0			+8		+2
1.0 to 40.0			+6		+1
6. Envelope Delay	SEC ref @ 6 Kz	See figure 1			
7. Nominal Data Input Signal Level	Volts Peak to Peak	1	1	1	1

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES (CON.)

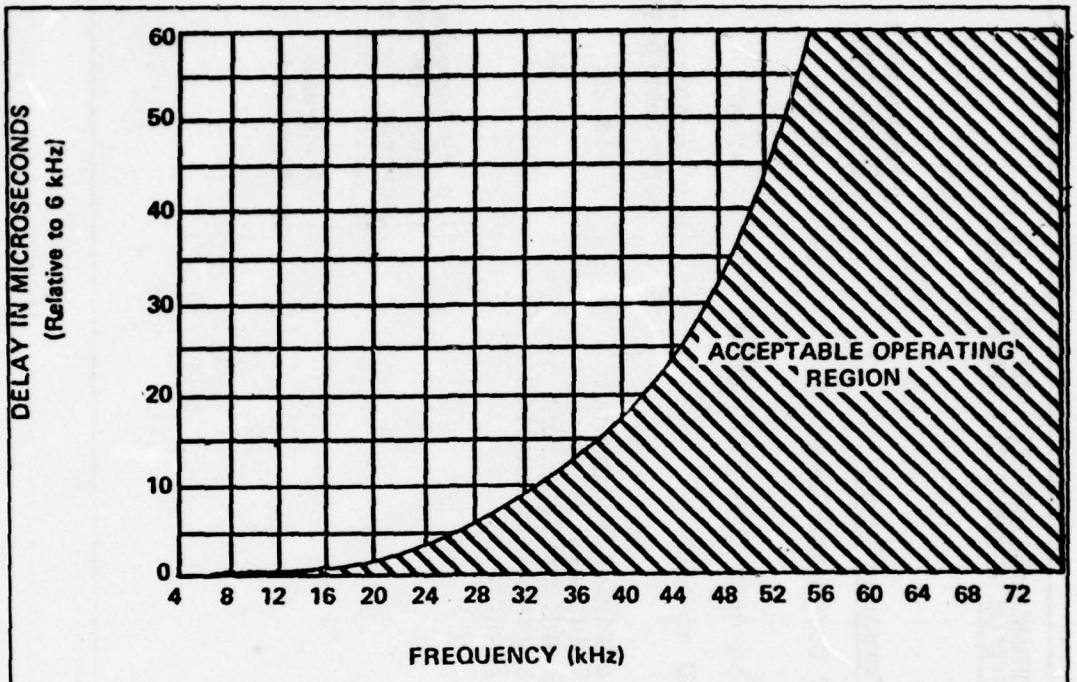
Z4 TECHNICAL SCHEDULE

(Z4 Parameter is for 50 kb/s long-distance circuits used between two switchboards over FDM or TDM radio carrier facilities. Special converters (842 data auxiliary set or CV 3034) are used to facilitate analog signaling over the channel.)

Characteristic	Unit of Measurement	Z4 Value
1. Error Rate Objective	Error Rate/ Time	See Note[17]
2. Channel Impedance	ohm	135 +10
3. Forward Switching Tone	Millisecond	400 (following end of last digit)
4. Jitter from Terminal Equipment (Maximum)	% Isochronous distortion, P-P jitter	20
5. Jitter to Terminal Equipment (maximum)	% Isochronous distortion P-P jitter, assumes 0-20% jitter from terminal equipment	33
6. Nominal Input and Output Data Signal Level	Volts Peak-to-Peak	1

[17]The burst error rate shall not exceed an average of one burst per minute measured as follows: No more than 15 fifty thousand bit blocks (1 second) in error during any 15 minute measuring period. An error block is one in which 9 or more bits are in error. This criterion corresponds to 98.3 percent error free seconds or an approximate BER of less than 3×10^{-5}. The measurement should be in terms of errored blocks or error free seconds.

Enclosure 1



NOTES.

1. Above curve represents envelope delay requirements. Limits are not specified below 6 kHz.
2. If the entire circuit consists of equalized twisted pair cable from which all loading coils and bridge taps have been removed, no delay equalization should be required. Given the correct frequency response over the range of .1 to 50 kHz (no discontinuities or sharp rolloffs), envelope delay will not normally be an item for concern on cable pairs.
3. Should the circuit contain carrier facilities, delay equalization must be employed so that the delay versus frequency response of the circuit is a smoothly and continuously increasing function of frequency, which falls within the shaded area of this figure.

FIGURE 1. RELATIVE ENVELOPE DELAY VS. FREQUENCY

Enclosure 1

TABLE 3. ELECTRICAL PERFORMANCE REQUIREMENTS APPLICABLE TO LINKS OR MULTILINKS WHERE OFFICIAL RECORDED DATA ARE AVAILABLE[1]

Parameter	Channel Performance Level	Permissible Deviation
a. Signal Level in VF Channel	(1) Data and VFCT Composite Level -13 dBmØ	±2 dB
	(2) Secure Voice in data mode -13 dBmØ	±2 dB
	(3) Voice -12 VU at ØTLP	Not to increase more than 6 VU
b. Idle Channel Noise in VF Channel	Value based upon official acceptance of the link or multilinks, value obtained during a major realignment or data obtained as a result of the DCS Technical Visits Program	+1Ø dB
c. Impulse Noise in VF Channel	Same as b. above	+1Ø dB increase in level or 20% increase number of noise counts
d. Phase Jitter in VF Channel	Same as b. above	+10% increase in Magnitude

[1]See paragraph 7b, basic Circular.

TABLE 3. ELECTRICAL PERFORMANCE REQUIREMENTS APPLICABLE TO LINKS OR MULTILINKS WHERE OFFICIAL RECORDED DATA ARE AVAILABLE[1] (CON.)

Parameter	Channel Performance Value	Permissible Deviation
e. Maximum change in Audiofrequency in VF Channel	Ø Hz	±2 Hz
f. Total telegraph distortion (including components of distortion such as bias, characteristics, fortuitous, etc.)	Same as b.	+5% increase in magnitude

[1]See footnote, page 24.

TABLE 4. ELECTRICAL PERFORMANCE REQUIREMENTS APPLICABLE TO LINKS OR MULTILINKS WHERE NO OFFICIAL RECORDED DATA ARE AVAILABLE[1]

Parameter	Channel Performance Value	Permissible Deviation
a. Composite Data or VFCT Signal Level in VF Channel	-13 dBmØ	±2 dB
b. Idle VF Channel Noise for Link or Multilinks of:		
0-80 kilometers (0-50 statute mi)	27 dBrnCØ, -61.5 dBmØ	+3 dB increase
80-161 (50-100)	31 dBrnCØ, -57.5 dBmØ	"
161-644 (100-400)	34 dBrnCØ, -54.5 dBmØ	"
644-1609 (400-1000)	38 dBrnCØ, -50.5 dBmØ	"
1609-2414 (1000-1500)	40 dBrnCØ, -48.5 dBmØ	"
2414-4024 (1500-2500)	42 dBrnCØ, -46.5 dBmØ	"
4024-6438 (2500-4000)	44 dBrnCØ, -44.5 dBmØ	"
6438-12874 (4000-8000)	47 dBrnCØ, -41.5 dBmØ	"
12874-25748 (8000-16000)	50 dBrnCØ, -38.5 dBmØ	"
c. Impulse Noise in VF Channel	15 counts per 15 minutes exceeding 62 dBrnCØ	+10 dB in level
d. Phase Jitter (Peak to Peak) in VF Channel	15 degrees	+1.5 degrees

[1] See paragraph 7b, basic Circular.

Enclosure 1

TABLE 4. ELECTRICAL PERFORMANCE REQUIREMENTS APPLICABLE TO LINKS OR MULTILINKS WHERE NO OFFICIAL RECORDED DATA ARE AVAILABLE (CON.)

Parameter	Channel Performance Value	Permissible Deviation
e. Maximum change in Audio Frequency in VF Channel	0 Hz	±2 Hz
f. Total telegraph distortion (including components of distortion such as bias, characteristic, fortuitous, etc.) derived via broadband facilities.[2]	5%	+5%
Single VFCT derived via HF Radio Facilities	20%	+5%

[1]See footnote, page 26.

[2]Signal regeneration should be applied when the signal distortion exceeds 25 percent.

APPENDIX D. ABBREVIATIONS

A	ampere
AC	alternating current
acq	acquisition
ADJ	adjust, adjusted, adjustment
ADV	advanced
AF	audio frequency
AFC	automatic frequency control
AGC	automatic gain control
ALC	automatic level control
ALM	alarm
AM	amplitude modulation
AMP	amplifier
AMP-HR	ampere-hour
AMPL	amplifier
AMSF	area maintenance supply facility
ASGD	assigned
ASSY	assembly
ASYNC	asynchronous
AT&T	American Telephone and Telegraph
ATT	attenuator
ATTEN	attenuator
AUTH	authorized
AUTO	automatic
AUTOXFMR	autotransformer
AUX	auxiliary
AV	average
AVE	average
AVG	average
AVGE	average
AWG	American wire gage
AZ	azimuth
BAL	balanced
BB	baseband
BCI	bit count integrity
BER	bit error rate
BERT	BER test set
BITE	built-in test equipment
BLDG	building
BP	bandpass
BPF	bandpass filter
B/S, b/s	bits per second
BTRY	battery
BTWN	between
BW	bandwidth
C	compliance, clock
CAL	calibration

CAP	capacitance, capacity
CCIR	International Radio Consultive Committee
CCR	Cmmunications Command regulation
C-E	communications-electronics
CEEIA	Communications-Electronics Engineering Installation Agency
CEN	center
CGA	carrier group alarm
CH	channel
CHAN	channel
CHAR	characteristic
CHNS	channels
CHS	channels
CKT	circuit
CLK	clock
CNDCT	conductor
COAX	coaxial
COEF	coefficient
COL	column
COND	conditioning
CONN	connector
CONT	contact
CONV	converter
CORR	corrected
CPB	circuit patch bay
CPLR	coupler
CRT	cathode ray tube
CT	circuit
CW	continuous wave
CXR	carrier
CY	calendar year
D	data
dB	decibel
dBc	decibels Collins
dBm	decibels referred to 1 milliwatt
dBmO	noise power referred to at zero relative transmission level
dBrn	decibels above reference noise
dBrnCO	weighted circuit noise power in dBrn, measured on a line with C-message weighting, referenced to a 0-dB test level point
dBw	decibels referred to 1 milliwatt
DC	direct current
DCA	Defense Communications Agency
DCAC	Defense Communications Agency circular
DCS	Defense Communications System
DCSS	Defense Communications System specification
DEG	degrees

DEMOD	demodulator
DEMUX	demultiplex, demultiplexer
DET	detector
DEVN	deviation
DIFF	difference
DISC	discriminator
DISCH	discharge
DISTN	distribution
DIV	division
DMS	delay measuring set
DO	desired objective
DPP	data patch panel
DSCRM	discriminator
DT	digital test
D/T	data/timing
DTG	digital timing generator
D-TO-A	digital-to-analog
DUR	duration
DUT	device under test
DVM	digital voltmeter
EAP	end around preparation
EF&I	engineered, furnished, and installed
EL	elevation
EMI	electromagnetic interference
EMER	emergency
ENG	engineer
ENGR	engineer
EQUIP	equipment
EXT	external, exterior
FASR	fault alarm status reporting
FDM	frequency division multiplex
FIL	filter
FLT	flat
FM	frequency modulation, field manual
Freq	frequency
FSK	frequency shift keying
FSV	frequency selective voltmeter
FSVM	frequency selective voltmeter
ft	feet
FUNC	function
FURN	furnished
G	group
GDF	group distribution frame
GEN	generator
GHz	gigahertz
GND	ground

GP	group
HF	high frequency
HFDF	high frequency distribution frame
HI	high
HMD	humidity
HOR	horizontal
HORIZ	horizontal
HP	Hewlett-Packard
Hz	hertz
I	input
ICN	idle channel noise
IF	intermediate frequency
IND	indicator
INF	infinity
INIT	initial
INJ	inject
INP	input
INTFC	interface
INTL	internal
INTR	interior
INV	inverter
I/O	input/output
ISOL	isolator
ITU	International Telecommunications Union
kb/s	kilobits per second
kHz	kilohertz
kVA	kilovolt ampere
kw	kilowatt
LDG	loading
LF	low frequency
LIN	linear
LO	local oscillator, low
LOF	loss of frame
LOG	logarithmic
LONG	longitudinal
LOS	line-of-sight
LP	low pass
LVL	level
MAX	maximum
mb/s	megabits per second
MBS	mission bit stream
MDN	median
MEAS	measured
MED	medium
MFD	manufactured
MFR	manufacturer
M-Ary	multiple way
mh	millihenry

MHz	megahertz
MIL-HDBK	military handbook
MIL-STD	military standard
MIN	minimum, minute
MLA	microwave link analyzer
MM	millimeter
MNL	manual
MOD	modulator
MODEM	modulator-demodulator
MON	monitor
MS	millisecond
MS'D	measured
msec	millisecond
MSG	message
MSL	mean sea level
MTBF	mean time between failures
MTTR	mean time to repair
MULT	multiplication
MULTR	multiplier
MUX	multiplex, multiplexer
mV, MV	millivolt
MW, M/W	microwave
N	number of units or parts
NA	not applicable
NC	noncompliance
NCOIC	noncommissioned officer in charge
NE	northeast
NEUT	neutral
NF	noise figure
NMS	noise measuring set
NOM	nominal
NPR	noise power ratio
NRZ	non-return-to-zero
nsec	nanosecond
O	output
O&M	operation and maintenance
ORF	operational readiness float
OSC	oscillator
OUT.	output
OW	orderwire
PA	power amplifier
PCM	pulse-code modulation
pF	picofarad
PHOTO	photograph
PIL	preferred items list
P/O	part of
POL	polarization
POS	position

p-p	peak-to-peak
PPB	primary patch bay
PPM	pulses per minute
pps	pulses per second
PREC	precision
PREP	preparation
PRFM	performance
PRI	primary
PROT	protective
PTF	patch test facility
PWR	power
QATD	Quality Assurance and Testing Detachment
QPR	quadrature partial response
QPSK	quadrature phase shift keying
RAD	radian
RC	resistive capacitance
RCV	receive
RCVD	received
RCVE	receive
RCVR	receiver
RDO	radio
REC	receive, receiver
RECD, REC'D	received
RECT	rectifier
REF	*reference*
REFL	reflection
REL	relative
REM	remote
REP	representative
REQT	requirement
RF	radio frequency
RMS	root mean square
RPM	revolutions per minute
RQR	require, required
RSL	received signal level
RX	receive
RZ	return-to-zero
SB	sideband
SCBS	service channel bit stream
SEC	second
SEL	selective
SER	serial
SG	supergroup
SIG	signal, signaling
S/N	signal-to-noise
SN	segment number

S/Nq	signal-to-noise quantizing
SNR	signal-to-noise ratio
SPDT	single-pole, double throw
SPECS	specifications
SPLTR	splitter
SSTS	solid state transfer switch
STA	station
STALO	stabilized local oscillator
SUPV	supervisory
SVC	service
SW	southwest
SWP	sweep
SWR	standing wave ratio
sync	synchronize, synchronization, synchronous
synch	synchronization
TBD	to be determined
TC	time-constant
TCF	technical control facility
TDM	time division multiplex
TDR	time domain refectometry
TDY	temporary duty
TECH	technician
TECHN	technician
TEMP	temperature
TEP	Technical Evaluation Program
TERMN	termination
TIMS	transmission impairment measuring set
TLP	test level point
TM	technical manual
TMDE	test, measurement, and diagnostic equipment
TMG	timing
TML	terminal
TMS	transmission measuring set
TOL	tolerance
TP	test point
TRANS	transmit, transmitter, transmitted
TRANSM	transmitter
TSEC	telecommunications security
TT	test tone
TTL	test tone level
TWT	traveling wave tube
TWTA	traveling wave tube amplifier
TX	transmit
TXR	transmitter
UNBAL	unbalanced
USACC	US Army Communications Command
V	volt
VAC	volts alternating current
VAR	variable

VC	voice channel
V. CH.	voice channel
VDC	volts direct current
VERT	vertical
VF	voice frequency
VFPB	voice frequency patch bay
VLTC	voltage level translating
VM	voltmeter
VPP	volts peak-to-peak
VRMS	volts root mean square
VSWR	voltage standing wave ratio
W	watt
WB	wideband
WTD	weighted
XFMR	transformer
XMIT	transmit
XMSN	transmission
XMT	transmit
XMTD	transmitted
XMTR	transmitter
XTAL	crystal
3LPR	three-level, partial response
µF	microfarad
µsec	*microsecond*

The proponent agency of this pamphlet is the Quality Assurance and Testing Detachment, US Army Communications Command. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) direct to the Commander, US Army Communications Command, ATTN: CC-OPS-OQ, Fort Huachuca, Arizona 85613.

FOR THE COMMANDER:

OFFICIAL

EUGENE J. VITETTA
Colonel, GS
Chief of Staff

BENNETT T. DINGWALL III
LTC, AGC
Adjutant General

DISTRIBUTION:

30 - CC-OPS-OQ
5 - CC-PA-AMP-P
2 - CC-LOG-LO-MM
20 - CDR, 5th Signal Command, ATTN: CCE-OP-CQ, APO New York 09056
15 - CDR, 2d Signal Group, APO New York 09086
15 - CDR, 160th Signal Group, APO New York 09164
1 - MGR, USACC Government Owned Contract Operated, Area Maintenance Support Facility, Europe, APO New York 09086
3 - CDR, 7th Signal Command, ATTN: CCN-PO-OQ, Fort Ritchie, MD 21719
1 - CDR, USACC-Forces, ATTN: CCNA-OP, Fort McPherson, GA 30330
1 - CDR, USACC-TRADOC, ATTN: CCNB-OP, Fort Monroe, VA 23651
1 - CDR, USACC Agency White Sands, White Sands Missile Range, NM 88002
5 - CDR, US Army Communications-Electronics Engineering Installation Agency, ATTN: CCC-PPRD, Fort Huachuca, AZ 85613
1 - CDR, USACEEIA-CONUS, Fort Ritchie, MD 21719
1 - CDR, USACEEIA-Europe, APO New York 09056
2 - CDR, 11th Signal Group (USACC), Fort Huachuca, AZ 85613
1 - CDR, USACC Japan, Camp Zama, Japan, APO San Francisco 96343
1 - CDR, USACC Japan Signal Support Activity, South, APO San Francisco 96331

DISTRIBUTION: (cont)

1 - MGR, USACC Japan Area Maintenance Support Facility, APO San Francisco 96331
10 - CDR, 1st Signal Brigade, APO San Francisco 96301
1 - CDR, USACC Operations Command, Rm 5A910, The Pentagon, Washington, DC 20310
1 - CDR, USACC-DARCOM, 5001 Eisenhower Avenue, Alexandria, VA 22304
2 - CDR, USACC WESTCOM, ATTN: CCP-OP, Fort Shafter, HI 96558
1 - HQDA (DAMO-ZA), WASH DC 20310
1 - HQDA (DALO-ZA), WASH DC 20310
1 - CDR, DCA-EUR, APO New York 09128
2 - CDR, DCA-PAC, Wheeler AFB, HI 96858
2 - DIR, Defense Communications Agency, ATTN: Code 500, Washington, DC 20305
1 - CDR, US Army Satellite Communications Agency, Fort Monmouth, NJ 07703
2 - CDR, US Army Communications and Electronics Materiel Readiness Command, Fort Monmouth, NJ 07703
2 - DIR, Defense Communications Engineering Center, ATTN: Code R210, 1860 Wiehle Avenue, Reston, VA 22090
12 - DIR, Defense Documentation Center, ATTN: Mr. D. S. Selland, Cameron Station, Alexandria, VA 22314
15 - COMDT, US Army Signal School, ATTN: ATSN-DT-M, Fort Gordon, GA 30905
2 - CDR, Air Force Communications Service, ATTN: DO, Scott AFB, IL 62225
2 - Third Mobile Communications Group, Tinker AFB, OK 73145
2 - CDR, Naval Telecommunications Command, 4401 Massachusetts Avé. NW, ATTN: Code 33, Washington, DC 20390
1 - CDR, Naval Communications Station, Division 34, Box 121, FPO San Francisco 96630